UTILIZING VOLUNTEERED GEOGRAPHIC INFORMATION TO ASSESS COMMUNITY'S FLOOD EVACUATION SHELTERS CASE STUDY: JAKARTA

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March, 2016

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Enschede, The Netherlands, March, 2016

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

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ABSTRACT

Volunteered geographic information (VGI) has been used in various research disaster responses due to its capabilities to provide near real-time information during the disaster. However, the use of VGI in the spatial planning in closely related to the disaster management, such as evacuation shelters planning was not often used yet. Utilizing VGI to captured community preferences of evacuation shelters could give a better understanding of community knowledge. The community preferences are integrated with expert criteria to assure the suitability of the site. This research investigates whether VGI can be used in assessing the site suitability of flood evacuation shelters. Jakarta, as the case study, has implemented VGI in flood emergency responses, and it has been determined as top 20 active cities in using the Twitter. Thus, Jakarta is an appropriate sample in term of using VGI for the shelter evacuation planning. Through geolocation Twitter data, which is performed as one of the VGI platforms, the location preferred by the community was identified. The Twitter dataset was also used to recognize the evacuees based on their tweet content. Those evacuees were asked to give their preferences related to the evacuation shelters to get the deeper understanding of preferences. From 171.046 tweets using the flood evacuation as related keywords, 310 tweets dealt with the evacuation shelters in Jakarta. The spatial pattern shows that those tweets mostly located near to flood area. There were 35,6% of the locations preferred by the community are intersected with the formal evacuation shelters. Based on the locations that could be identified, the site suitability assessment was conducted using the criteria from the local experts. Accessibility determined as the most preferred criteria both by the community and the local expert. As a general evaluation of the VGI, its shows the advantages through its easiness on capturing community preferences of evacuation shelter locations in the large coverage area.

Keywords:

Evacuation shelter, Flood, Volunteered Geographic Information, Jakarta

ACKNOWLEDGEMENTS

I would first like to express my appreciation to my supervisors Dr. Diana Reckien and Drs. Jeroen Verplanke for the valuable advice and critiques. They have been constantly supporting and gave guidance for sometimes I am getting lost.

I would like to thank The Chairman of the thesis assessment board, Prof. Dr. Ir. M.F.A.M. van Maarseveen, contribute by giving comments and recommendations. The sceptical to Twitter has encouraged my curiosity about the VGI.

I would also to thank Dr. Richard Sliuzas and Dr. Johannes Flacke, for their advice at the beginning of my proposal formulation. The discussion on choosing the thesis topic has given me various ideas and to narrowed it down.

Dr. Ate Poorthuis who gave the Twitter data as the primary source of this research. With this dataset, I could get deep on exercising the usefulness of VGI.

All the staff of UPM and ITC for new knowledge how to see an urban problem in various point of view.

I would also like thank to all colleagues at Jakarta Capital City Government. To all in City Planning Department and Jakarta Disaster Management Agency for the support during fieldwork. Also for the ideas and all the data that easily accessed.

Finally, I would give my very profound gratitude to my support system: my family, best friends and to all that I could not mention. With your unconditional support, I could pass through the challenges of being student, wife and mom all at once.

Enschede, March 2016

Adya Ninggar Laras Kusumo

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LIST OF ABBREVIATIONS AND ACRONYMS

API : Application Programming Interface

BPBD : *Badan Penanggulangan Bencana Daerah* (Disaster Management Agency of Jakarta)

Bappeda : *Badan Perencanaan Pembangunan Daerah* (Jakarta Planning Board)

DPK : *Dinas Penataan Kota* (Jakarta City Planning Department)

IAP Jakarta : Ikatan Ahli Perencanaan (Indonesia Association of Urban and Regional Planners of Jakarta

NGO : Non-Governmental Organizations

SMCA : Spatial Multi Criteria Analysis

VGI : Volunteered Geographic Information

1. INTRODUCTION

1.1 Background

The evacuation plan is one of the crucial parts in preparedness to reduce the impact of the flood. The U.S Department of Transportation (2013) mentioned that appropriate evacuation plans might save lives and reduce personal suffering. Provision of flood shelters, as mentioned by Rashid, Haider, and McneilL (2007) is a critical issue that needs to be considered. An evacuation shelter is giving protection to the people affected by the disaster and provides basic needs during an emergency (CCCMCluster, 2014). Therefore, Greiving and Fleischhauer (2006) mentioned that planning evacuation shelters as one of the inputs to the spatial plan.

Early approaches regarding evacuation shelter planning were based on expert-based knowledge. The analysis conducted for evacuation shelters was site selection based on their suitability. In terms of analysing suitability for locating evacuation shelter, spatial multi criteria (SMC) have been developed based on expert knowledge (Alçada-Almeida, Tralhão, Santos, & Coutinho-Rodrigues, 2009; Kar & Hodgson, 2008). However, Perry (1979) mentioned that expert knowledge about the planning of evacuation shelters often differs from community preferences. Community preferences have a crucial role regarding flood risk reduction. Toyoda and Kanegae (2014) mentioned that communities usually are the first responders during disasters. Therefore, preferences of communities in relation to their awareness of suitable locations for evacuation shelters were very important. Hence, combining expert and community-based approaches in evacuation shelter planning might contribute to enhancing resilience to the hazard (UNISDR, 2005).

Some research has demonstrated the combinations of expert knowledge and community knowledge regarding evacuation shelter planning. However, few studies put emphasis on actual behaviour during flood event. Yazici and Ozbay (2008) mentioned that people's behaviour is usually estimated through surveys conducted under non-disaster conditions with people affected by previous disaster. Understanding people's behaviour under disaster conditions could be represented from secondary data that is directly supplied by people being affected.

Volunteered Geographic Information (VGI) has been used in many cases of disaster response. VGI could be relied upon due to its capabilities to provide near real-time information, which is crucial during the occurrence of a disaster (Erskine & Gregg, 2012; Goodchild & Glennon, 2010). Moreover, VGI provides data in a large coverage area and involves a numerous individual and communities (Horita, Degrossi, Mendiondo, Ueyama, & Porto de Albuquerque, 2015). Therefore, the use of VGI might be an approach to capture information on personal behaviour with regards to evacuation shelters under-disaster conditions.

1.2 Research Problem

Communities tend to have their preferences for using certain evacuation shelters. Evacuation shelters that are preferred by the community sometimes differ from the formal evacuation shelters. Capturing community knowledge and integrating it with expert knowledge, was one of the challenges in planning evacuation shelters (UNHCR, 2007). To have a better understanding of community knowledge and preferences of evacuation shelters based on actual disaster conditions would reduce this challenge.

VGI has been used in several emergency responses in different countries because it provides near real-time information (Li & Goodchild, 2010; Meier, 2012). However, using VGI in spatial planning related to disaster management, such flood evacuation shelter planning, has not been used often yet. Utilizing VGI data to capture preferences of evacuation shelters might give a better understanding of community knowledge.

Moreover, to integrate community preference of evacuation shelters with the expert knowledge, the location (based on VGI) should be assessed on the basis of their site suitability according to expert criteria. Spatial multi criteria was conducted in site suitability assessment. Thus, combining location of community choices and the ideal criteria of local experts might increase community resilience for future flood hazards. Figure 1 shows the conceptual framework of the research.

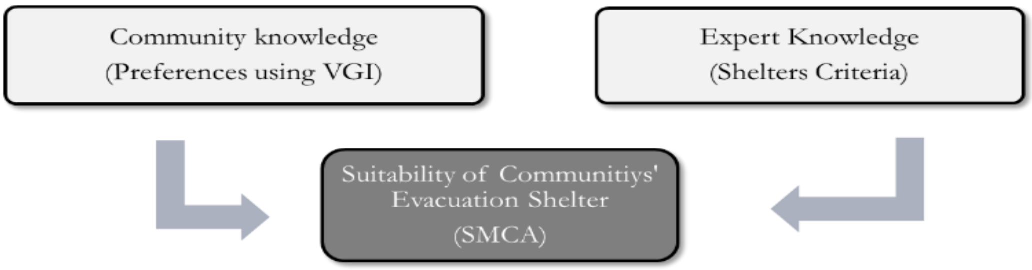


Figure 1 Conceptual Framework

1.3 Case Study

Flooding has been an issue in Jakarta since the colonial era. Based on historical records, major floods are occurred in 1654, 1872, 1909 and 1918 (Team Mirah Sakethi, 2010). Currently, floods happen nearly every year. In 2002 and 2007 Jakarta was severely flooded with the high impact of 50 years cycle period. According to Firman, Surbakti, Idroes, and Simarmata (2011), the 2002 flood covered about one-fifth of the Jakarta's total area. Hundreds of thousands of people were homeless, 68 persons were killed, and 190,000 people had flood-related illnesses and about 422.300 people evacuated. Flood losses were estimated at nine trillion Indonesian Rupiahs (USD 998 million) (Akmalah & Grigg, 2011).

Several programmes have been developed by the local government to reduce the loss that caused by the flood event. One of the actions, Jakarta has established spatial planning that includes flood evacuation shelter plan. The evacuation shelters utilized the function of government asset such schools, government buildings and public spaces. Nonetheless, based on the previous flood event, the evacuation shelter used by the community, some of them was not in the formal evacuation shelter that allocated by the spatial plan. The communities tends to have their preferences on evacuation shelter.

Moreover, Jakarta province government has also implemented the use of VGI in flood emergency responses. The system was called "Peta Jakarta" which provided by Jakarta Government in collaboration with Peta Jakarta co., and Twitter. Peta Jakarta (@petajkt) was a system that attached to social media to gather, sort, and display information about flood event in Jakarta in real time (BPBD Jakarta, 2015). Also, by using this platform, Jakarta's residents can easily give a report related to the condition of their neighbourhood. The report included flood events, evacuation processes, traffic jams, and other information of urban problems.

One of the reason behind the development of the VGI in Jakarta was the enormous use of in this capital city. Semiocast (2012) launched the research about the use of Twitter as one of the significant social media. Based on Semiocast (2012), Jakarta took the first place of top 20 cities for the number of posted tweets in 2012. From 10.6 billion public tweets posted in June 2012, more than 2% of it came from Jakarta (Please refer to Figure 2).

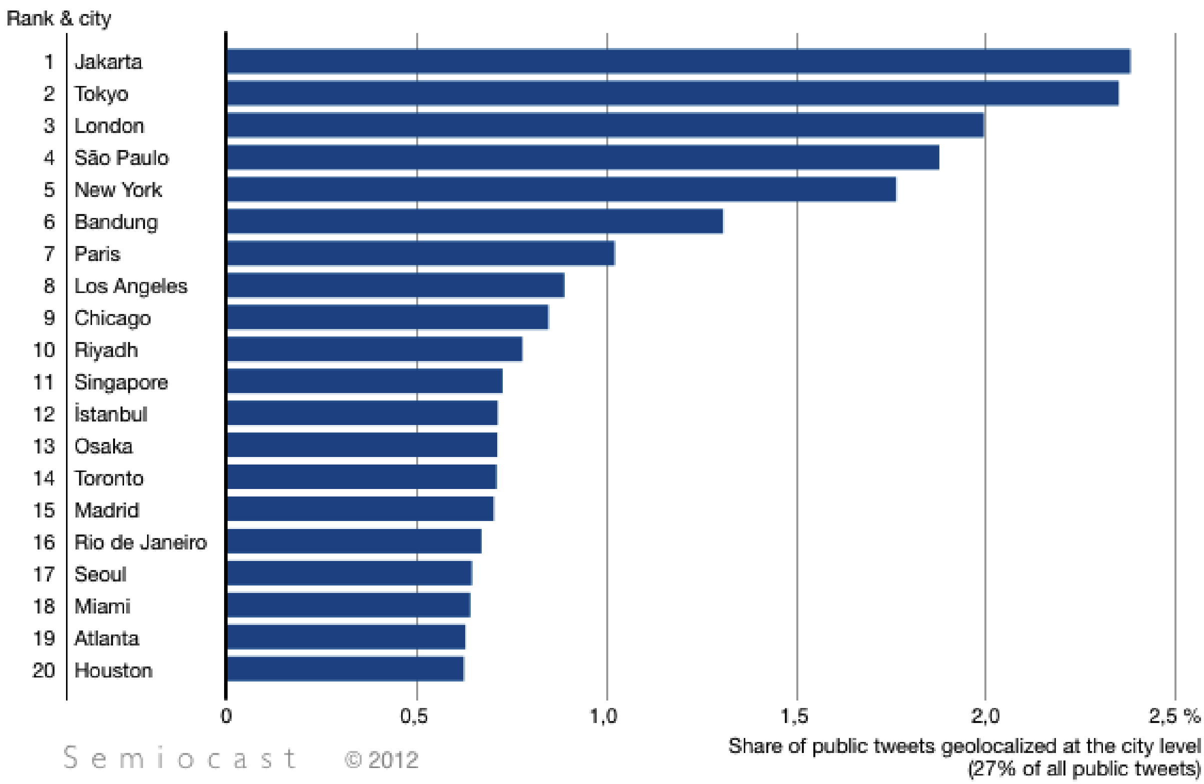


Figure 2 Top 20 cities by number of posted tweets (Semiocast (2012))

1.4 Research Objectives

The general objective of this research is to determine whether VGI can be used in assessing site suitability of flood evacuation shelter in Jakarta. Based on the general objective, four specific objectives are being observed:

1. To generate the dataset of community's evacuation shelter from VGI (Twitter).
2. To determine community preferences on evacuation shelter.
3. To assess site suitability of community's evacuation shelter based on criteria of the local expert.
4. To evaluate the usefulness of VGI data in assessing site suitability of community's flood evacuation shelter.

1.5 Research Questions

The following research questions are being identified as to answer research objectives:

1. To generate the dataset of community's evacuation shelters from VGI (Twitter).
   a. How to generate data of evacuation shelter from VGI?
   b. What is the spatial pattern of mentioned evacuation shelters in VGI?
2. To determine community preferences on evacuation shelters.
   a. How do the comparison of community's preferences of evacuation shelters compare to the formal evacuation shelter?
   b. What are the preferences of the community for selecting evacuation shelters?
3. To assess site suitability of community's evacuation shelters based on criteria of the local expert.
   a. What are the criteria local expert use to assess the site suitability of evacuation shelters?
   b. What are the weights for each criteria according to local experts?
   c. What are the site suitability of the evacuation shelter preferred by the community?

   d. What is the relation between local expert's criteria and the community's preferences regarding evacuation shelter?
4. To evaluate the usefulness of VGI data in assessing site suitability of community's flood evacuation shelter.
   a. What is the benefit of using VGI in assessing site suitability of community's flood evacuation shelter?
   b. What is the drawback of using VGI in assessing site suitability of community's flood evacuation shelter?
   c. Do the benefits of using VGI outweigh the drawbacks in assessing site suitability of community's flood evacuation shelters?

1.6 Structure of The Thesis

This thesis is divided into five chapters. The chapters are the introduction, literature review, methods and research design, results and discussion and conclusion. Following are the description of each chapter:

1. **Chapter 1: Introduction**

   This chapter describes the background of the research, research problem and case study of the research, research objectives and research questions.

2. **Chapter 2: Literature Review**

   This chapter describes the concept related to this research. The literature related to evacuation shelter planning, volunteered geographic information and spatial multi criteria analysis.

3. **Chapter 3: Methods and Research Design**

   The chapter on methods and research design explain the study area of the research, data collection method and data processing and analysis method.

4. **Chapter 4: Results and Discussion**

   This chapter describes the results of the research and its discussion. Start with the result of community's evacuation shelter from volunteered geographic information based on Twitter, site suitability of evacuation shelter preferred by the community using criteria of a local expert, the usefulness of VGI data in assessing flood evacuation shelter by the community and finalised with the limitations and improvements for future assessments.

5. **Chapter 5: Conclusion**

   This section describes the conclusion for further research.

2. LITERATURE REVIEW

2.1 Evacuation Shelter Planning

Evacuation shelters is one of the important factor during disaster event. An evacuation shelters should be support safety and protection from ill and disease for the evacuee (The Sphere Project, 2011). Moreover, it also necessary to become a place for people to recover from the disaster. According to UNHCR (2007), there are three categories of emergency refugee settlements:

1. **Dispersed settlements or host families**. This kind of settlements is occupied the house of evacuee's relatives on their neighbourhood.
2. **Mass shelter**. Evacuees are using several type of facilities e.g. schools, barracks, hotels, gymnasiums or warehouses. This type of settlements is within the urban area and become a temporary shelter.
3. **Camps (spontaneous and planned)**. Spontaneous camp is built without a site planning. This type of camp is to accommodate evacuee in critical time. It might located in anywhere without consideration of environmental friendly. Meanwhile, planned camp is well planning accommodation facilitated with several services e.g. toilet and water.

Each type of evacuation shelters are need a good planning, to assure the safety of the evacuees. Evacuation shelter planning should integrate a knowledge of specialist and the sights of the evacuees (UNHCR, 2007). According to (UNHCR, 2007), the planning process should be done through the bottom up approach by knowing the preference of the community.

Evacuation shelter planning are includes the site selections which consider their suitability. There are several criteria should be considered in term of convinced suitability of the location. Many criteria mentioned by expert. CCCMCluster (2014), mentioned the criteria of evacuation shelter as the availability of facilities, accessibility, safety, capacity and number of persons. In more technical, Kar and Hodgson (2008), summarized criteria of flood evacuation shelter from several sources. Those criteria are located outside the flood zone, proximity to highways and evacuation routes, distance to the hazard sites (e.g. industrial area) and the proximity to health care facilities.

As an international guidance on evacuee, UNHCR (2007) mentioned three categories and criteria for evacuation sites. Firstly, the location (e.g. distance from major towns, distance from the border, security and protection, local health, etc.). Secondly, basic characteristics of the site (area, land use, topography, elevation, water availability, drainage, etc.). Lastly, complementary/supportive points (accessibility, proximity to national services, electricity, etc.). Moreover, The Sphere Project (2011) has also developed the categories of standard. The standard are strategic planning, physical planning, covered living space, design, construction and environmental impact. Table 1 shows the summary of evacuation shelter suitability criteria based on literature.

Table 1 Literature related to suitability criteria of evacuation shelter site

Category	Sites Criteria	Detailed Criteria (if any)	Parameter						
			1	2	3	4	5	6	7
Availability of Facilities	Water	An adequate amount of water on a year-round.	+	-	√	-	-	-	-
	Waste	Minimum distance 30 m	-	-	-	-	-	-	+
Capacity	Size of shelter sites	Minimum surface area is 45 m^2 per person (including kitchen/vegetable gardening space) or not less than 30 m2 per person (excluding garden space)	+		√	-	-	-	
		Minimum usable surface area of 45 m^2 for each person including household plots should be provided.		+					
		Minimum 3 m^2 per person							+
Land use, building code and land right	Land use and land rights	Sites are provided on public land by the government.	+	-	√	-	-	-	-
Security and protection	Distance from international borders		-	-	√	-	-	-	-
	Away from potential and secondary hazards	The closer a shelter was to a hazardous facility, the less suitable.	-	-	√	-	+	-	-
	Distance from military installations		-	-	√	-	-	-	-
Topography, drainage and soil conditions	Slopes	Above flood prone area (2% – 4%)	+		-	-	-	-	-
		<5%		+					
	Soil conditions	Excessively rocky or impermeable sites	+	-	-	-	-	-	-
	Flood Zone	Should not be located in a 100 or 500-	-	-	-	+	-	-	-
Accessibility	Proximity to health care services	Locations that close to health facility are more desirable	-	-	-	-	-	+	-
	Proximity to the main road	Locations that close to major transportation routes is more suitable	-	-	√	+	-	√	-
	Proximity to secondary road		-	-	-	-	-	√	-
	Proximity to the home	as close as possible	-	-	+	-	-	-	-
	Proximity to population	Regions with a population density of 24 people per square kilometre (equivalent to three families/km2) are considered.	-	-	-	-	-	+	-
	Distance from each shelter	The distance depends on access, proximity to the local population, water supplies, environmental considerations and land use and rights.	+	-	-	-	-	-	
Climatic conditions, local health and other risks	Local health condition	Free of major environmental health hazards	+	-	-	-	-	-	
	Climatic conditions	Suitable site in the dry season may be untenable in the rains.	+	-	-	-	-	-	
Vegetation	Ground cover	Sufficient	+	-	-	-	-	-	

Sources:
1. UNHCR (2007)
2. The Sphere Project (2011)
3. CCCMCluster (2014)
4. FEMA (2015)
5. ARC (American Red Cross) (2002)
6. Gall (2004)
7. National Disaster Management Authority (BNPB) (2008)

Notes:
(+) adopting the criteria with parameter
(√) adopting the criteria
(-) not adopting the criteria

2.2 Volunteered Geographic Information

Volunteered Geographic Information (VGI) was an approach to provide geographic information. VGI allows people to contribute their sights regarding to geographic information and take a part in the participatory process (Goodchild, 2007). Many platforms categorised as VGI e.g. geolocated Twitter, Flickr and OpenStreetMap (Schade et al., 2011).

Various research discussed the relation between participatory mapping and VGI. Brabham (2009) mentioned that there are differences between VGI and other participatory land use mapping. The main distinction is people not only designed the solution but also assess them. Moreover, Tulloch (2008), stated that in public participatory GIS allow people to evaluate the dataset of public policy, but in the VGI, people tend to participate in developing the data. Moreover, according to McCall, Martinez and Verplanke (2015), in relation to degree of participatory, VGI provide a large number of people involvement in small time compared to other participatory GIS.

The use of VGI was extended in a various branch. VGI has been adopted in many cases of disaster emergency response. The speed of VGI made this approach used in the disaster planning and preparedness. According to Takahashi, Tandoc, and Carmichael (2015), due to the speed of VGI, it becomes reliable for coordination in a disaster event. Takahashi et al., (2015), also mentioned that there are several usage of VGI in a disaster report by the community, requesting help, and criticizing the government.

The advantage of VGI also used in several case of urban planning (Brabham, 2009), for instance the people participation on validating the land use/cover in the urban area. In term of urban planning, the endorsement of VGI by the government also seen in many cases. The government use the VGI as a platform to accommodate report from the community. Hence, the usage of VGI by the government has several challenges (Johnson & Sieber, 2013). The main challenge is how to accept the accuracy of the data provide by the community.

Another concern of VGI research is the ethic of reusing the data. Data from the Twitter, for instance, there are still debatable by many researchers. White and Roth (2010), mentioned that information sent by people using Twitter has reduced the privacy of the information. They added that people did not aware on the reuse issue of the information they sent. Moreover, to prevent confidentiality of the user, their identity should not be published (Moreno, Fost, & Christakis, 2008).

Twitter messages have its specific component and structure. In using Twitter for social analysis, we should understand each structure of the content. Twitter contained of the name, username, profile photo, the text of tweet, picture, time and date stamp and also geotagged (Please refer to Figure 3). Moreover, Poorthuis, Zook, Shelton, Graham, and Stephens (2014) mentioned that there is a structure in Twitter that could be used in geographical research there are geotagged location, information about the user and textual and content of the Twitter.

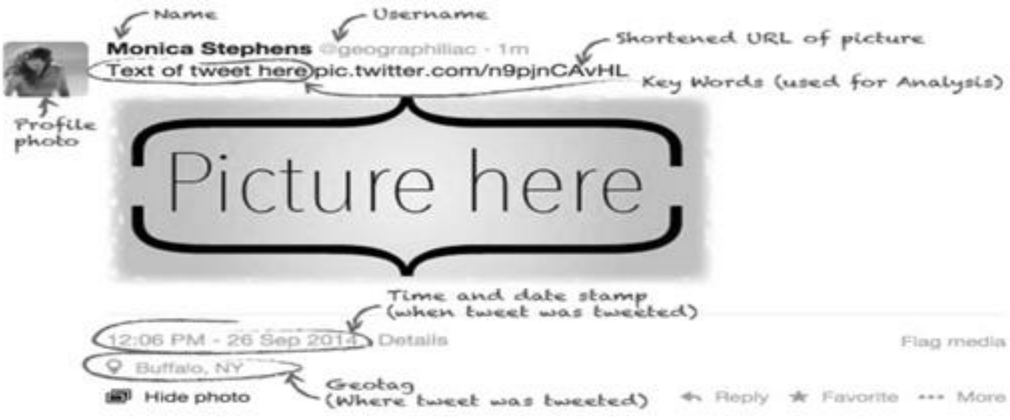


Figure 3 Twitter structure (Poorthuis, Zook, Shelton, Graham, & Stephens (2014))

2.3 Spatial Multi Criteria Analysis

Multi-Criteria Analysis (MCA) or often called as Multi-Criteria Evaluation is a method used to determine the number of alternatives along with several criteria (Carver, 1991). Carver (1991) mentioned that various cases in planning comprised with plenty of factors. For instance, to identified site locations. MCA that focuses on the spatial factor was called Spatial Multi-Criteria Analysis (SMCA). Adopting SMCA might assist the location of space-related problems.

SMCA has been used in various research. Tsangaratos, Rozos, Ilia, and Markantonis (2015) used SMCA method to determine urban suitability. Meanwhile, van Haaren and Fthenakis (2011), identifying site location for a wind farm. Related to urban public facilities, Taleai, Sliuzas and Flacke (2014) adopted SMCA to evaluate the equity of public facilities. In the case of disaster risk reduction, SMCA has also used in some research. Armas, Dumitrascu, and Bostenaru (2010) studied the vulnerability of seismic hazard in an urban area in case of a seismic hazard. Furthermore, Feizizadeh, Shadman Roodposhti, Jankowski and Blaschke (2014), was identify landslide vulnerability using SMCA. Specific to evacuation shelter planning, Wood, Jones, Schelling and Schmidtlein (2014) studied about tsunami evacuation shelter location with SMCA methods.

The process of SMCA were mainly divided into several phase (Rahman & Saha, 2008). First, Boolean overlay is combined all criteria using logical operators such as intersection (AND) and union (OR). After that weighted operation are involved. In this phase also carried out the process of standardization of criteria score. The result of summation is below:

$$S = \Sigma\, WiXi \qquad \text{Eq 1}$$

Where S is the suitability, Wi is the weight of the criteria, and Xi is the criterion score of criteria i.

To measure the sensitivity of the SMCA, sensitivity analysis should conduct. According to Carver (1991), sensitivity analysis was a determination to indicate how sensitive if the criteria or weights were changes. Moreover, Ligmann-Zielinska & Jankowski (2008) mentioned the main changes to examine sensitivity analysis was the alternative changes, criteria changes, weighting changes and the evaluation method e.g. standardization techniques.

3. METHODS AND RESEARCH DESIGN

3.1 Study Area

The study area for this research is the Province of Jakarta, the capital city of Indonesia, located in 5°19'12" - 6°23'54" S and 106°22'42" - 106°58'18" E. Total area of Jakarta Province is 662 km^2 and consist of five administrative cities (mainland) and 1 administrative coastal region (islands on the northern part of the mainland). In this research, the area is only included 5 administrative cities (mainland) and without the administrative coastal region. The five cities of Jakarta Province has 42 district. The map of the study area can be seen in Figure 4.

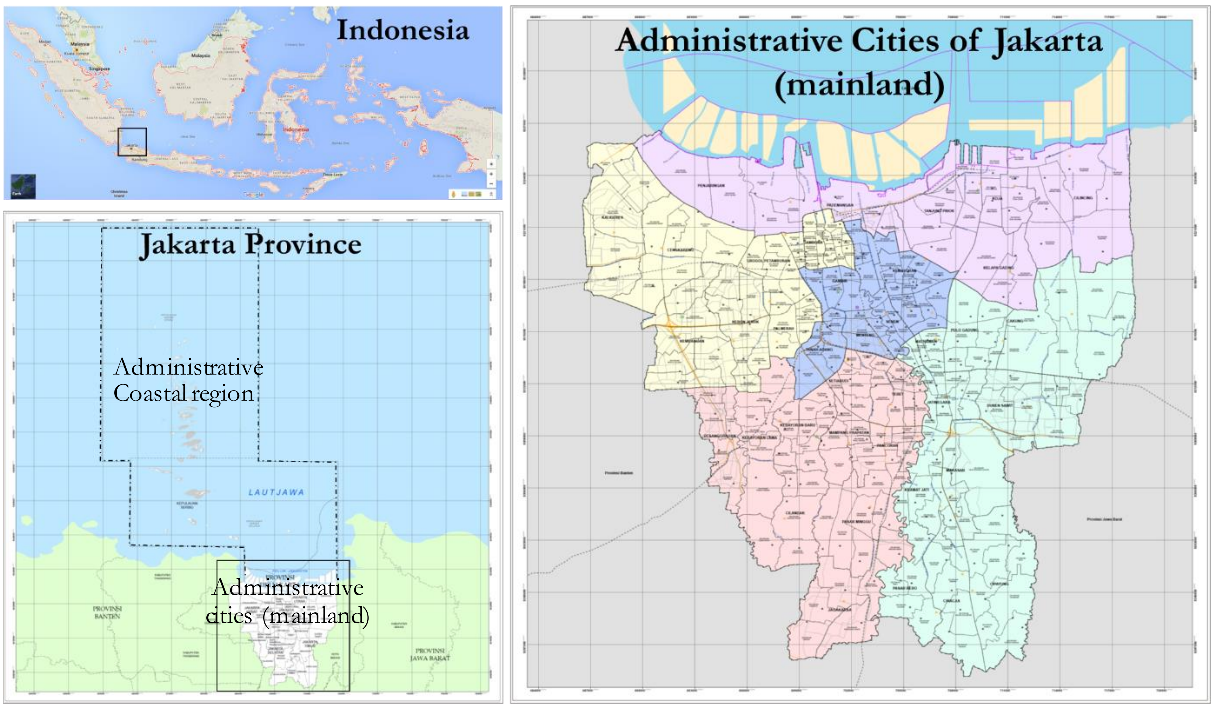


Figure 4 Map of Jakarta Administration (Google, 2015 & Jakarta Capital City Government, 2014)

3.2 Data Collection Method

The data used in this research comprised both spatial and non-spatial data. It collected from various sources, and it is vary according to a particular objective.

3.2.1 Data of Community's Evacuation Shelter from VGI (Twitter)

The data related to the community's evacuation shelters derived from the VGI data. The VGI used the Twitter data as the sources. It retrieved from API Twitter obtained by the DOLLY (Digital OnLine Life and You) archive (Poorthuis et al., 2014). DOLLY was the storage place of massive geolocated Twitter data (Zook, Graham, Shelton, Stephens, & Poorthuis, 2016). Figure 5 shows the flow of data retrieved by DOLLY.

Figure 5 Flow of twitter data retrieval (adopted from Zook et al., 2016)

3.2.2 Data of Community Preferences on Evacuation Shelters

This research used the primary data to capture the community preferences. The data gathered from the questionnaire that were sent to a specific respondents. Those respondents were particularly people who sent information through Twitter related to evacuation shelter locations and they were identified as evacuee. They were asked several questions regarding to their preferences of evacuation shelters which have been used by them in previous flood event (Please refer to the Appendix 1 for the full questionnaire form). The questionnaire was designed in Survey Monkey platform. The link to the Survey Monkey questionnaire was given to the respondent through their Twitter account. The questionnaire is mixed between the open-closed questions.

Another data was the secondary data related to the distribution of formal evacuation shelters. It was collected from Jakarta Disaster Management Agency and Jakarta Spatial Planning Department. The data was used to compare the community preferences with the formal evacuation shelters.

3.2.3 Data on Assessing the Site Suitability of Evacuation Shelters Preferred by the Community

Local experts were involved to formulate the criteria of community evacuation shelter suitability sites. The expert sampling was conducted to select the specific local expert. Expert sampling is a way to involving persons with experience or knowledge in certain area (Trochim, 2006). They were asked their preferences regarding to criteria and weight regarding to suitability of the evacuation shelter sites suitability. The local expert were representing several institution in Jakarta, which closely related to disaster risk reduction and evacuation shelter planning in Jakarta. Following (Table 2) are the experts and their role:

Table 2 List of local expert

Local Expert	Role
Disaster Management Agency of Jakarta (BPBD)	Coordinating the disaster management in Jakarta
Jakarta City Planning Department (DPK)	Coordinating the detailed spatial planning in Jakarta include evacuation shelter planning
NGO	Developing the activity plans in discussion with local people and other collaborators specifically evacuation shelter planning
Indonesia Association of Urban and Regional Planners of Jakarta (IAP Jakarta)	Organizing the planners in Jakarta
Disaster Risk Management Specialist	Formulate the evacuation shelter planning (as an expert)

To assess the suitability of evacuation shelter sites, the data that used were based on the final criteria from the local expert. Those data such as flood area (2007 and 2014/2015), road network (highway, main and local), flooded zone, and land use plan. This secondary data obtained from several institution. According to the criteria of suitability, following (Table 3) shows the data and sources that needed as an input for the analysis. All the map were used WGS 1984 UTM Zone 48S coordinate system.

Table 3 Data of Suitability Criteria

Category	Data	Description	Year	Scale	Source
Accessibility	Primary road	National level road	2014	1:5.000	Jakarta City Planning Department
	Secondary road	Provincial level road	2014	1:5.000	
	Local road	Neighbourhood level road	2014	1:5.000	
	Residential area	Residential land use	2014	1:5.000	
Topography, drainage and soil condition	Flood area	Flood area map from previous flood event	2002, 2007, 2013/2014, 2014/2015	(aggregate of neighbourh ood level)	Jakarta Disaster Management Agency,

Category	Data	Description	Year	Scale	Source
					Jakarta Planning Board
	Slope	Slope with 5%	2015	1:3.000	Open DEM
Availability of facilities	Electricity power station	Power station distribution in provincial level	2014	1:5.000	Jakarta City Planning Department
	Flood area	Flood area map from previous flood event (aggregate of neighbourhood level)	2002, 2007, 2013/2014, 2014/2015	(aggregate of neighbourhood level)	Jakarta Disaster Management Agency, Jakarta Planning Board
Land use, building code and land right	Land use of public area	Land use plan of public area	2014	1:5.000	Jakarta City Planning Department
Security and protection	National vital object	Object that indicated as national vital object (e.g. military zone, presidential zone, strategic industrial zone)	2014	1:5.000	Jakarta City Planning Department
	Industrial area	Distribution of industrial area indicated as secondary hazard	2014	1:5.000	
	Land use zone	Land use type map (residential, commercial, industrial, government, facilities, etc.)	2014	1:5.000	Jakarta City Planning Department

3.3 Data Processing and Analysis Method

Several method were conducted in processing and analysing the data. According to each objective, following sub-chapters discussed the process of the analysis (Figure 6).

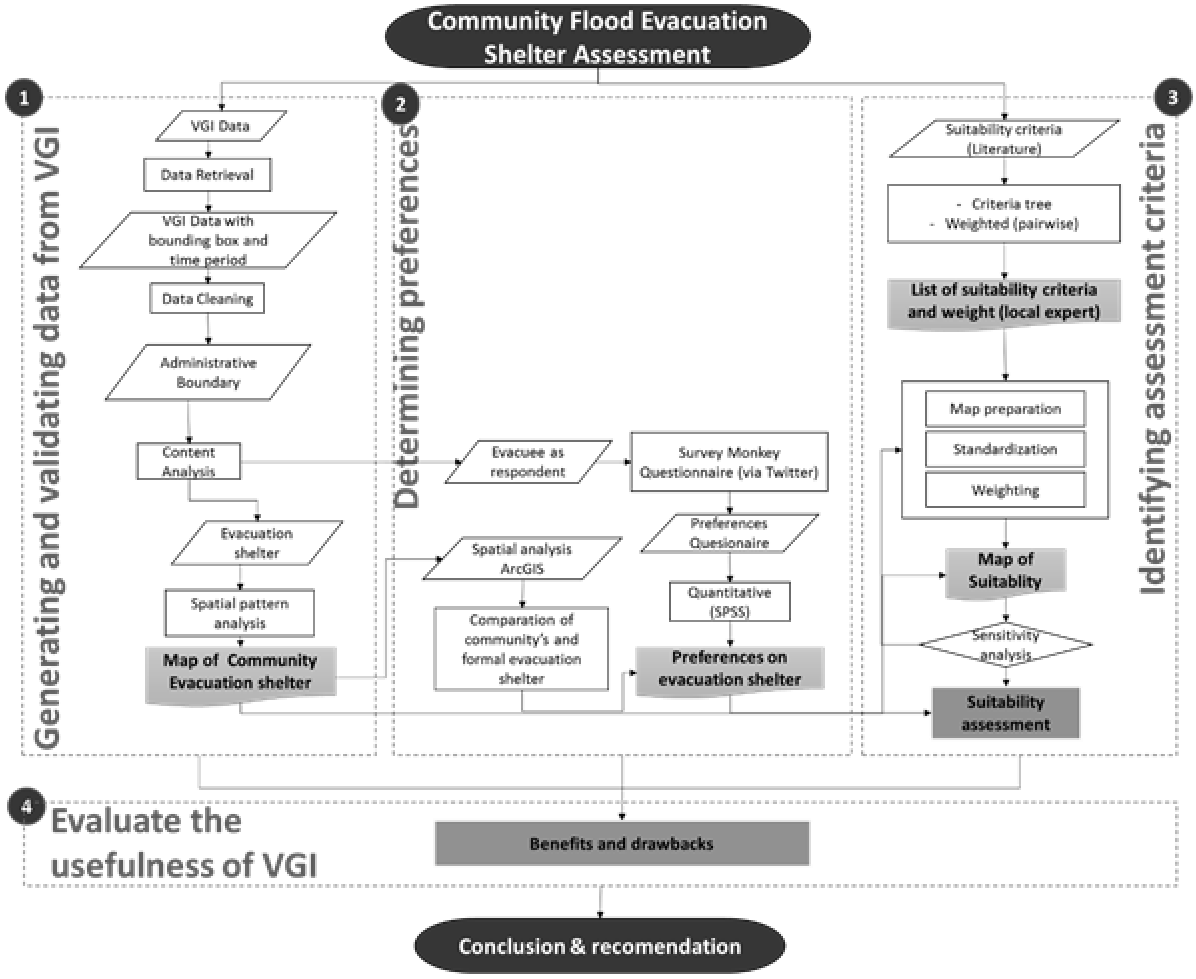


Figure 6 Methodological Flowchart

3.3.1 Analysis on Generate and Validate the Data of Community's Evacuation Shelters from VGI

The aims of this part was generating the dataset from Twitter. It consists of three stages adopted from Vidal, Ares, Machín and Jaeger (2015), which were retrieval data, data cleaning analysis and content analysis. The output data was used to analysed their spatial pattern. The description of each stage are as following:

1. Data retrieval and cleaning

   The Twitter data was retrieved from DOLLY (Zook et al., 2016) by using Twitter API. It was similar with Durahim and Coşkun (2015), which mentioned that Twitter API is the most common method to gather the data from the Twitter. The data were those located inside the bounding box of Jakarta on -5.20166N, 106.974274E, 6.37248S, and 106.390266W. To obtained specific flood period, this research used period of previous flood event which assigned by BPBD Jakarta (2015), as the emergency response phase in Jakarta. The latest flood event was from December 2013 to March 2014 and December 2014 to March 2015. After the twitter data was retrieved the data was cleaned with the administrative boundary of Jakarta Province.

2. Content analysis

   Manual coding was done in the content analysis stages. The method to analyse the content of VGI data was text based analysis with coding. Walsh (2003) mentioned that by using coding, we can make a label that related to our focus into the classification. The deductive approach was conducted, and it started by predefined relevant keyword from the expert, e.g. #banjir (flood) and #evakuasi (evacuation) (Holderness & Turpin, 2015).

The content analysis divided into two parts. First, the content analysis of relevance tweets[1] related to evacuation shelters. Atlas TI Software was used as the tools. The aim of this part is to filter the tweets that contextually relevance to the flood evacuation shelters in Jakarta. Second, the content classification analysis from those relevance tweets. The process also used Atlas TI but with open coding approach. The aim of the content classification was to filter the location of evacuation shelters as precise as possible. Content classification also intent to identified the evacuee as the respondents.

3. Spatial pattern

Spatial pattern analysis was conducted by overlying the evacuation shelters from the Twitter data with flood area map. Since the twitter data was generated from 2013/2014 and 2014/2015 the map of flood area was also within those years. In ArcGIS, analysing the spatial pattern was held. However, people only where sent the information (tweets) related to the evacuation shelters, but not certainly the actual location of evacuation shelters itself. Therefore, the tweets should be converted into the spatial unit. Thus, the actual location could be analysed their site suitability.

Different form of a spatial unit from Twitter dataset were obtained. From point feature, administrative boundary aggregation to the hexagon normalization (Poorthuis et al., 2014). To choose the proper spatial unit type, it highly depend on the purpose of the research. The purpose of this research was to analyse the site suitability of evacuation shelters. Various research used spatial unit that is representing the shelter sites e.g. building unit or land use unit (Chang & Liao, 2014; Gall, 2004; Kar & Hodgson, 2008).

On selecting the most appropriate spatial unit, it was necessary to consider the positional accuracy. Many studies observed the accuracy of the VGI (Goodchild & Li, 2012). Haklay (2010) compared the Open Street Map with survey data. As a result, the average deviation of the location was 6 meters. Hence, in this research, the accuracy assessment should be conducted. Accuracy assessment in VGI can be added if the data can become control data (Comber et al., 2013). In this study, we tested the distance between geolocation and the actual location mentioned in twitter text. Purposive sampling was held in accuracy assessment. Tweets that mentioned clearly the location within the text was chosen. Then, the mean distance of the actual location and geolocation became the basis to choose the spatial unit.

3.3.2 Analysis to Determined Community Preferences on Evacuation Shelters

Analysis of community preferences on evacuation shelters was conducted using the quantitative method. The analysis was combined with the spatial analysis from the twitter dataset. Further, analysis of preferences also compared with formal evacuation shelter distribution. Thus, we could conclude how community and formal evacuation shelter might differ.

3.3.3 Analysis to Assess the Site Suitability of Evacuation Shelters Preferred By the Community

As the first step of suitability analysis was to derive the criteria. The list of criteria from the literature provided as a guidance for the experts. Every experts choose the criteria that the most important according to their perspective. The criteria should also be relevance to implemented in Jakarta. The criteria that those chosen by 70% of the expert or at least 3 or more expert mentioned, are selected as final criteria. Afterward,

[1] The tweets are terminology in Twitter as a content of it. The tweets consist of texts, photos, videos and links (Twitter, 2016)

the same experts were asked again to give weighted on each criteria. The method in giving the weight was performed in pairwise analysis. The pairwise analysis was held on mobile application called "Priest" from android (Figure 7). Mobile application made the weighting process easier and transparent. After the local expert give their preference, they could directly see the result of their choices in the device.

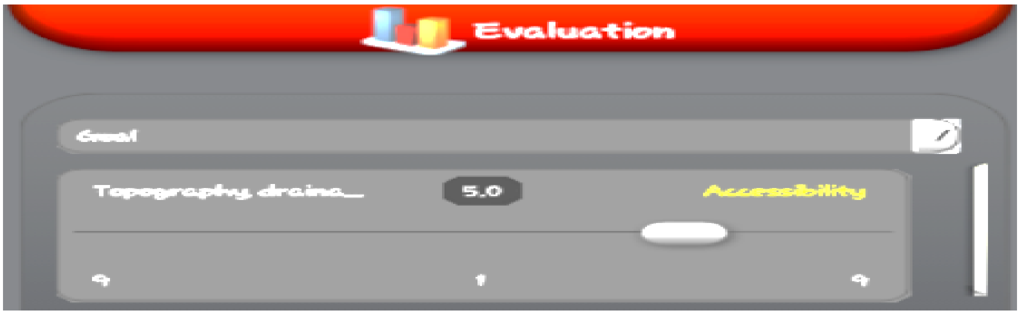


Figure 7 Pairwise using Priest Application on Mobile

Pairwise comparison is easy to interpret by the expert but needs consistency in the usage. This analysis done by compare the possible pairs of factors, give the weight of each and inconsistency ratio (Rahman & Saha, 2008). In this case, the expert gives a comparison between each criterion of suitability and converted to a quantitative value of scale from Saaty (1977) (Table 4).

Table 4 Pairwise value

1/9	1/7	1/5	1/3	1	3	5	7	9
Extremely	Very Strongly	Strongly	Moderately	Equally	Moderately	Strongly	Very Strongly	Extremely
Less Important					More Important			

To assess the suitability of evacuation shelter based on community preference, Spatial Multi Criteria Analysis was conducted in Community-Viz. This method combined an information that obtained from various criteria into one evaluation index (Rahman & Saha, 2008). According to them, several steps to guiding the analysis is criteria input, a group of criteria as criteria tree, standardized and weighted. The output of the SMCA was several maps for each criterion and composite index maps.

In this research, each community's evacuation shelter was assessed their sites suitability. Every suitability class was ranked into three ordinal classes (low suitable, medium suitable and high suitable). The method to classify the suitability was used the mathematical approach which depends on the type of data distribution (Kraak & Ormeling, 2010). If the data distribution was in normal curves, standard deviation classification method was the choice. If the curve was linear, then the equal interval was obtained. Another type of data distribution was arithmetic and geometric curves, which fitted in using natural breaks method. Moreover, except the distribution of the data, to identify the classification method should also consider the purpose of the map (Knippers & Mank, 2015). Figure 8 shows the difference curve of the data distribution.

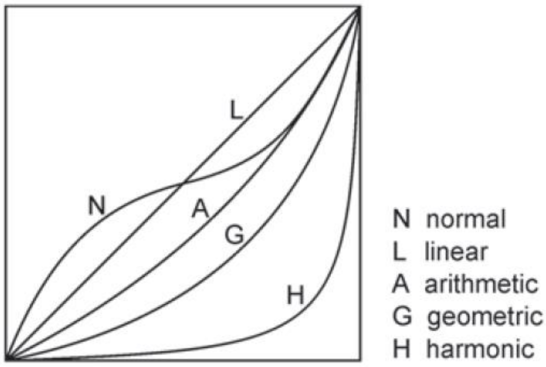


Figure 8 Curves with common functions (Kraak & Ormeling, 2010)

To conduct the sensitivity analysis, we determined the changes in criteria and weight. By adding or deleting some of the criteria which might be used to observe the sensitivity of the model (Ligmann-Zielinska & Jankowski, 2008). In this case, the criteria being deleted was the least mentioned by the expert. At the end, the suitability of evacuation shelter was confronted by the reason from community preferences.

3.3.4 Evaluating The Usefulness of VGI Data in Assessing Sites Suitability of Community's Flood Evacuation Shelters

To evaluate the usefulness of VGI in assessing site suitability of community's flood evacuation shelter was obtained in the qualitative analysis. The benefits and drawbacks of using VGI were identified based on the process this research. For each step of analysis, the usefulness of VGI was identified.

4. RESULT AND DISCUSSION

4.1 Community's Evacuation Shelters from Volunteered Geographic Information (Twitter)

4.1.1 Data Generated of Evacuation Shelters from VGI

Generating data from Twitter contained three steps which were data retrieval, data cleaning and content analysis. Figure 9 shows the result of data generated.

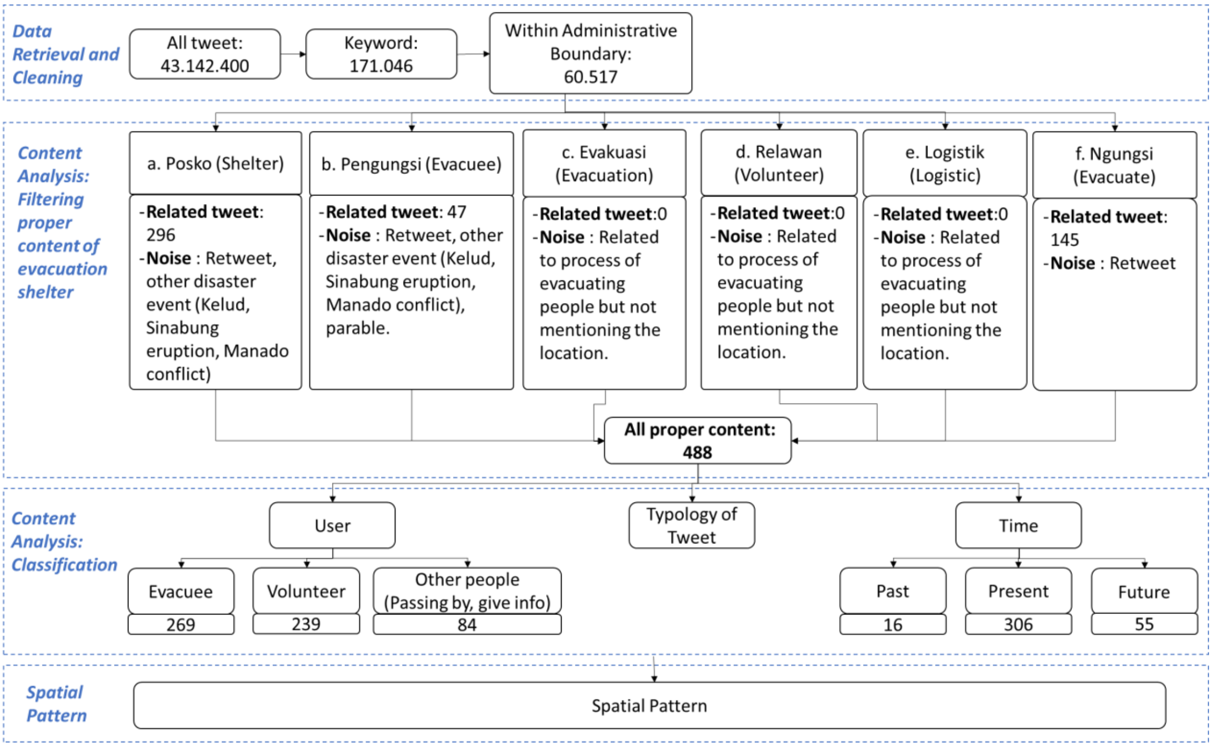


Figure 9 Twitter Data Generated

The data that retrieved from the Twitter are used various hashtags and keywords, i.e. #banjir, #banjirjkt, #evakuasi, #logistik, #relawan, pengungsi, korban, @petajkt (according to interviewed with petajakarta.org). Approximately 135.885 tweets created between December 2013 to March 2014 and 35.160 tweets in December 2014 to March 2015. Based on the data, data cleaning was generated to clipped the data which only within the administrative boundary of Jakarta. About 60.517 tweets were inside administrative boundary of Jakarta (Figure 10).

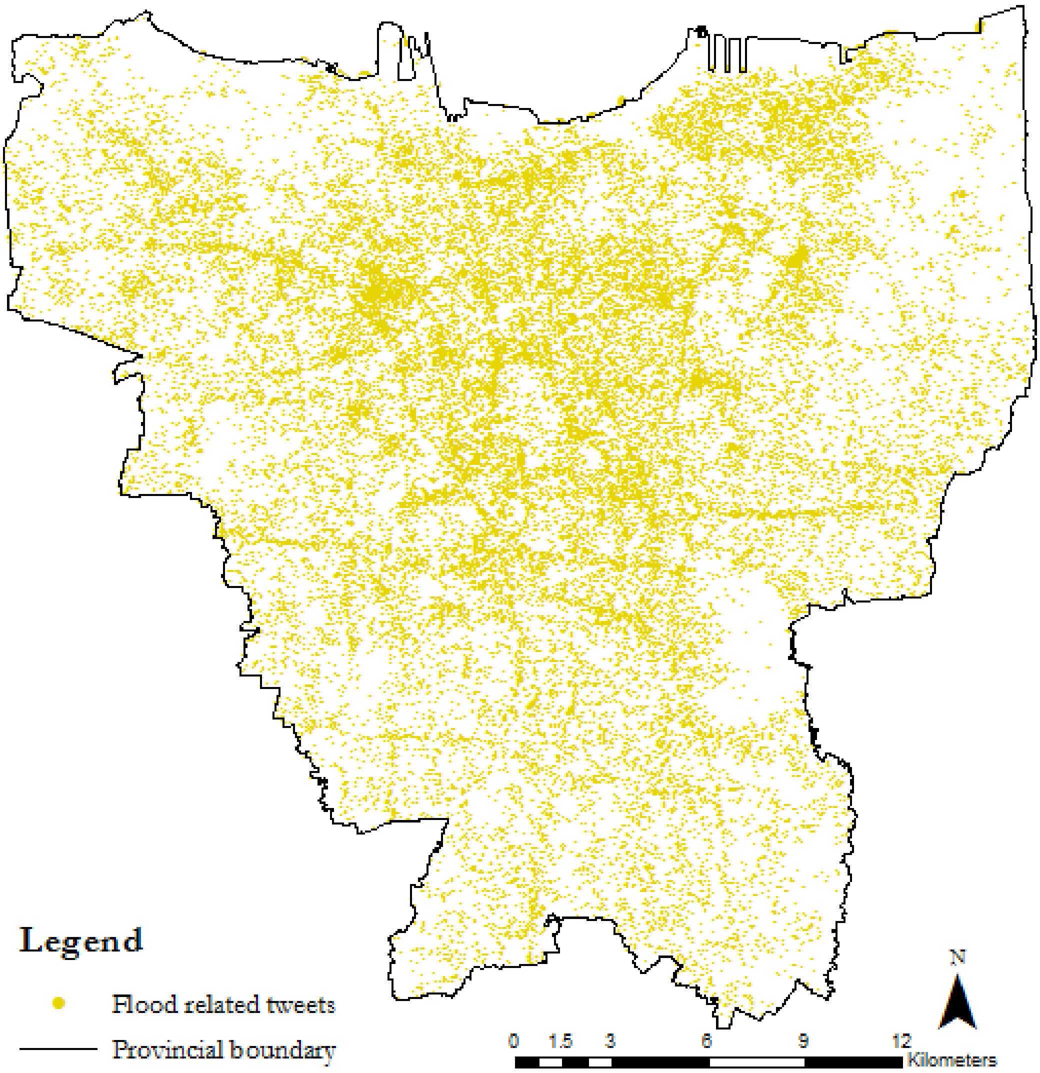
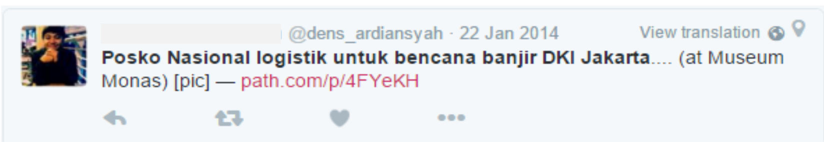


Figure 10 Tweets related flood 2013/2014 and 2014/2015 (Data: Zook et al., (2016))

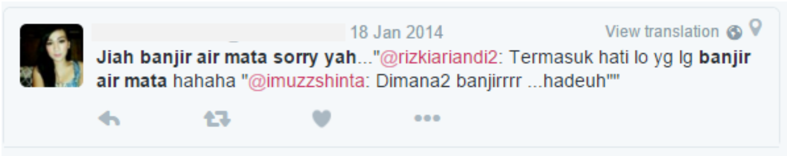
The first steps in the content analysis was to filter relevance content related to the evacuation shelters. By using the same keyword (posko, pengungsi, evakuasi, relawan and logistik), people mostly mentioned keyword "posko" (shelter) with 291 tweets (sample shown in Figure 11) and "pengungsi" (evacuee) with 47 tweets. None of the relevance tweets were using "evakuasi" (evacuation), "relawan" (volunteer) and "logistik" (logistic). To understand the content mentioned by people, we figured out that there was other keywords that should also be considered. The keyword is "ngungsi" (evacuate). By using this keyword, more evacuation shelter tweets could be identified. About 145 tweets were mentioned by people. The suffix word of each keyword should also be identified in this analysis.



"National logistic shelter for flood in DKI Jakarta…(at Museum Monas)"

Figure 11 Twitter Sample of "Posko" (Shelter) (www.twitter.com)

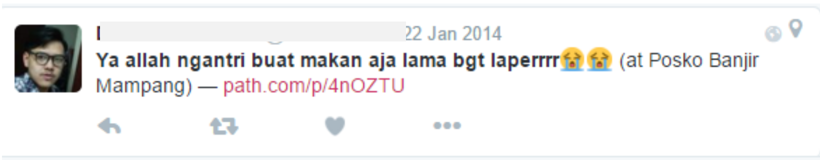
There were several "noise" mentioned by people on their tweet. Irrelevance information that seen in the content included other disaster events e.g. Mount Kelud and Mount Sinabung eruption and Manado conflict event. Some people also mentioned retweet, which only repeated information from others. Another noise could be identified was the metaphor of the keyword. Figure 12 shows the sample of metaphor word.



"Floods of tears, sorry…"

Figure 12 Twitter Sample of Metaphor (www.twitter.com)

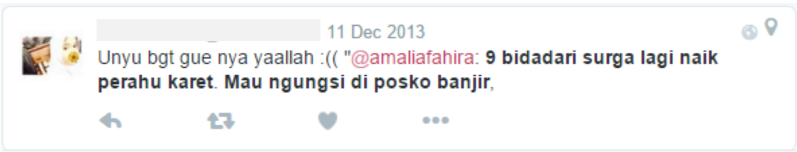
From the dataset of relevance content related to evacuation shelters, content classification were held. The result of the analysis could be classified in three category: User, Time and Typology of Tweet. The user consists of "Evacuee", "Volunteer", and "Other People". Figure 13 shows Tweet sample of the evacuee. In some cases, evacuee and volunteer could not be identified their differences, such several tweets mentioned only "I am at evacuation shelter". This type of tweet could not differ as evacuee or volunteer. "Other people" were contained people that only passing by the evacuation shelters. This category also people who only gave information related to the evacuation shelters.



"Oh God. What a long queue to get some food. I'm starving (at Mampang Flood Evacuation Shelter)"

Figure 13 Twitter Sample of Evacuee, Volunteer and Other People (www.twitter.com)

The category of time consists of "past", "present" and "future". The present was the information that people were really at the evacuation shelters at the time they were tweeting. The "past" or sometimes called "late post" included tweet by people after they were visited evacuation shelters. On the other hand, the future was tweet by people before they came to the evacuation shelters (sample in Figure 14). Data from "the past" and "the future" could give information on how far people would go to the evacuation shelters.



"Dear God, how cute I am☹. 9 angels are on the safety boat going to evacuation shelter"

Figure 14 Twitter Sample of Future (www.twitter.com)

Based on the analysis above, 306 tweets of the location of evacuation shelters could be identified. Those locations are tweet both from evacuee, volunteer and others but in present time. By only included present time, identification of evacuation shelter could be more accurate.

Choosing the most proper keyword was an important part of the content analysis in twitter data. Finding proper keyword was an iteratively processed. Several factor should be as consideration. First, in filtering content of twitter, should consider the synonym of each word. Some people used another word with the same meaning. Slang word should also be deal with, especially when the users were young people. Second, the use of adjective, verb, noun and adjective of the same word are included in searching the content of the tweet. Another factor was the metaphor word. The same keyword could give many connotations. All the keyword were influenced by the characteristic of each language. Although manual content analysis has conducted thoroughly, however missing content and irrelevance content still might include.

4.1.2 Spatial Pattern of The Dataset Generated from Twitter

There are 306 tweets that could be recognized as the tweets of evacuation shelter locations in 2013/2014 and 2014/2015. By overlaid the tweets data with the flood map of 2013/2014 and 2014/2015, we could analyse the distribution where people were tweeting.

The tweets of 2013/2014 were apparently clustered in where the flood was occurred (Figure 15). There were concentrations of tweets in central of Jakarta. This location was most severely affected from the flood event. This location was Kampung Pulo neighbourhood in Jatinegara District. Some areas in Kampung Pulo were the catchment area of the biggest river in Jakarta, Ciliwung River. Since long time ago the catchment area was inhabited by the low-income people as slum area. It was typical that slums were occupied in the rainwater accumulation areas (Kit, Lüdeke, & Reckien, 2011). Therefore, Kampung Pulo was at high risk of flood based on the characteristic of the social economic (Khomarudin, Suwarsono, Ambarwati, & Prabowo, 2014). The higher risk of Kampung Pulo in compare with other location in Jakarta made volunteer concentrated to give their aid and set up evacuation shelters.

In compare with 2013/2014 flood event, the 2014/2015 flooded area was less broad. The less flood event in this year was in line with the tweets traffic related to the evacuation shelter. There were only 48 tweets mentioning evacuation shelter. The distribution of the tweets also dispersed in several locations throughout the city. In overlaying with 2014/2015 flood area, some of the tweets were not in the flood area (Figure 16).

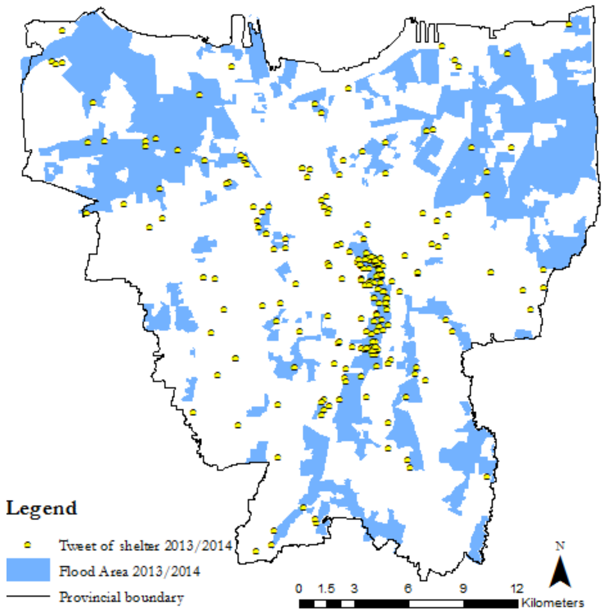


Figure 15 Tweets of Evacuation Shelter and Flood Area 2013/2014 (Data: Jakarta Disaster Management Agency, Jakarta Planning Board, Zook et al. (2016). Source: own analysis)

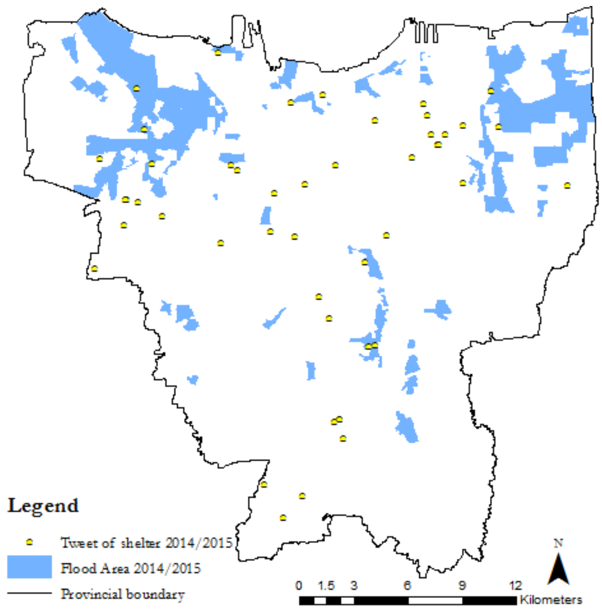


Figure 16 Tweets of Evacuation Shelter and Flood Area 2014/2015 (Data: Jakarta Disaster Management Agency, Jakarta Planning Board, Zook et al. (2016). Source: own analysis)

Based on 306 tweets related to the evacuation shelter, 86 tweets mentioned the detailed location of evacuation. These 86 tweets being used as a sample to calculate the mean distance between the geolocation and the actual location based on the content of the tweets. As a result, the distance was between 0 to 5.405 meters, with the average of 188,28 meters distance (please refer to Appendix 6).

Since there was amount distance between the geolocation and the location, we should put this consideration when choosing the spatial unit. To accommodate the distance between geolocation and location, each tweets point should convert into the general spatial unit to be analysed further. This also anticipated the possibility of several tweets with different geolocation but mentioned the same location within the text. There was several type of spatial unit which could accommodate the mean distance of 188,28 meters. Buffer, hexagon and the land use zone were some of them. In this case, we limited the analysis on two spatial unit that could be useful in further analysis (related to suitability analysis).

First, the land use zone (Figure 17). The formal evacuation shelters in Jakarta performed in land use zone spatial unit. The land use zone spatial unit in Jakarta were the area of 3 m² to 3 km². However, there was a problem in converted twitter data to land use zone. If we directly converted the point of tweets into land use using spatial join without any buffering, the result would be biased. For instance, if the geolocation was differ with the location mentioned in the twitter text, then there will be missed interpretations of land use zone. The cut-out on the right hand side of Figure 16 shows the example of biased interpretations. Some of the tweets were relatively near to the formal evacuation shelters and the tweets might actually in the formal evacuation shelter. But since there is mean distance of geolocation, thus it might snapped on the other land use zone. As the consequences, we could assess the wrong land use zone.

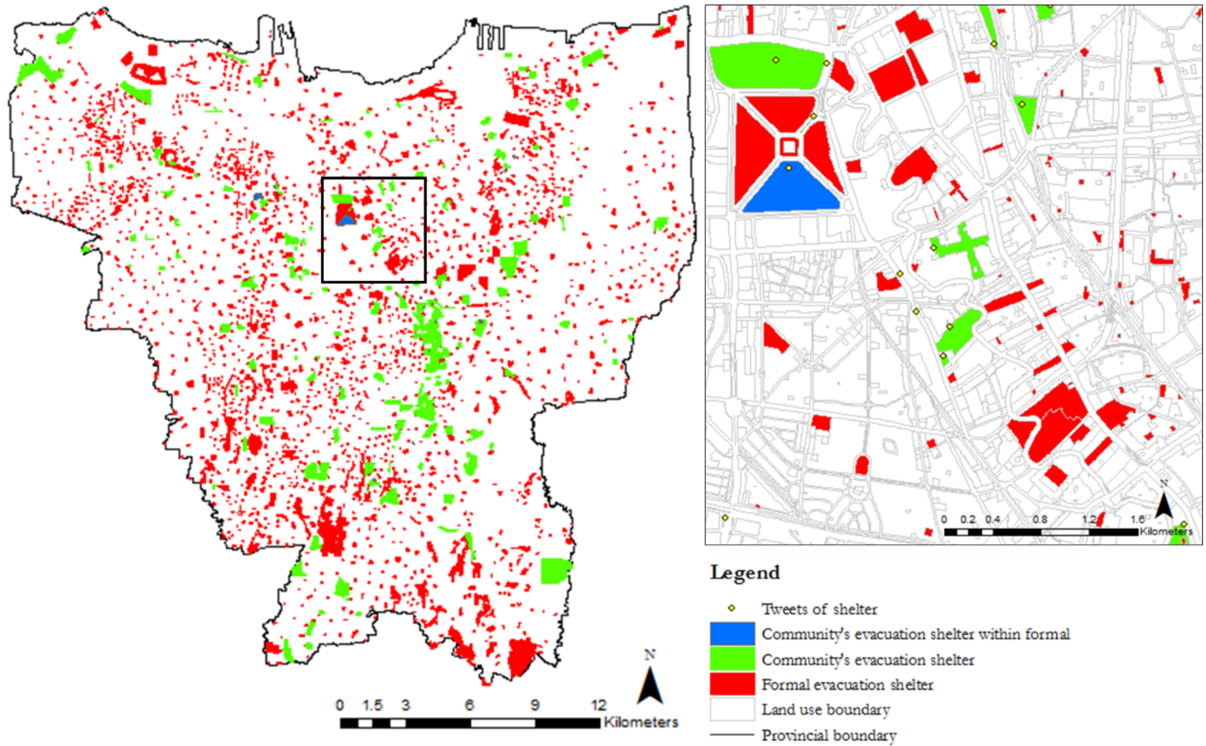


Figure 17 Land use zone spatial unit of evacuation shelter sites (Data: Jakarta City Planning Department, Zook et al., (2016). Source: own analysis)

Hexagon tessellations were type of visualization that used for simplifications (Raposo, 2013). The width of hexagon has conformity. According to Birch, Oom and Beecham (2007), there are several advantages of hexagon tessellations than regular grid. Hexagon tessellations has more symmetric nearest neighbourhood since the length of each line was equal. It also has better clearness on the visualization.

In this research, the hexagon was used the equal length side of 200 meters. This was based on 188,28 meters mean distance between geolocations and actual locations. From 306 tweets of community's evacuation shelters (points), there were 215 hexagons of community's evacuation shelter sites after converted (Figure 18). Those 215 hexagon could be called as the actual location of community evacuation shelters.

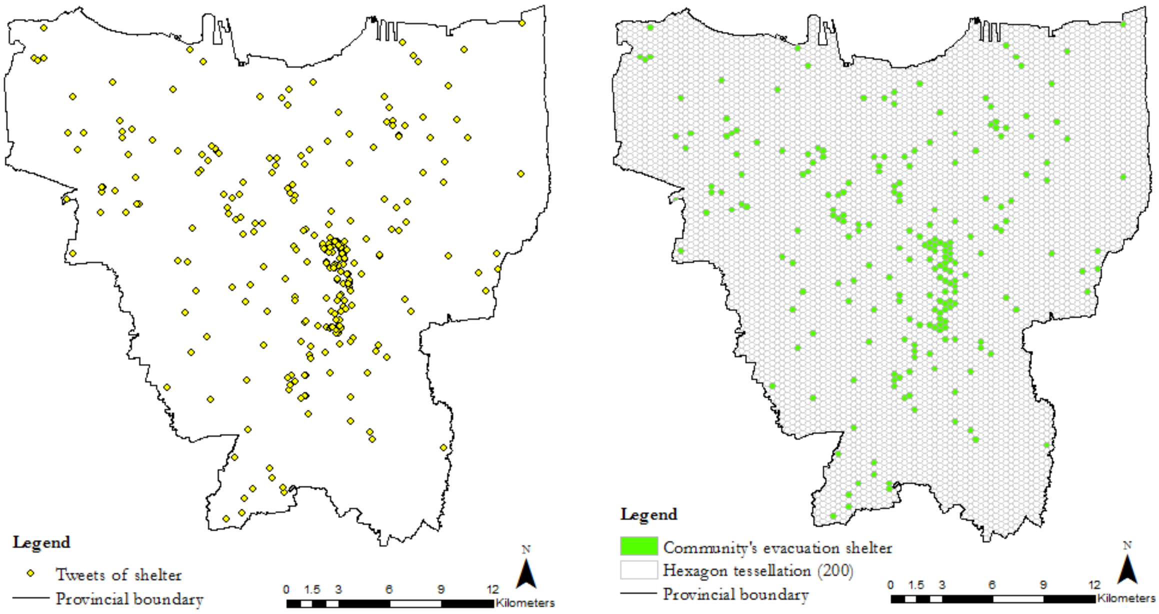


Figure 18 Conversion from tweets (point) into the actual evacuation shelter sites (hexagon)

4.2 Community Preferences on Evacuation Shelter

Determining community's preferences for evacuation shelters was analysed from the questionnaire combined with the spatial pattern analysis of the hexagons. The respondent for the questionnaire were generated from people identified as the evacuee in Twitter data. About 269 relevance tweets could be identified as the evacuee. However, those evacuee might have possibility of being mixed with the volunteer tweets even the deeper content analysis had been done. Those 269 tweets from the evacuee, were sent by 184 twitter account. Means that some accounts sent several times of tweets. Through those twitter account, the link of Survey Monkey questionnaire were sent.

Several challenges were encountered in getting the feedback from the respondent. First, people tend to ignore the questionnaire. In this case, we need to send them several reminder within 5 days. After sent reminder for 6 times, only 3 accounts gave feedback on their preferences of the evacuation shelter (please refer to Appendix 2 for the result). Another challenge was the limited number of characters (140) in Twitter, restricted us on giving an introduction of the research.

4.2.1 Comparison Between Formal and Community's Preferences Regarding Flood Evacuation Shelters

By comparing community's evacuation shelter sites and formal evacuation shelters, we could get an overview how people using formal evacuation shelters. Based on the spatial plan, there were 2.645 locations of the formal evacuation shelters. The formal evacuation shelters was in the land use zone spatial unit, which differ with the spatial unit of the community's evacuation shelter sites (hexagon). So that, we could not easily define that the community used or not used the formal evacuation shelter.

To deal with this issue, we analysed the spatial join between formal and community evacuation shelter sites. Formal evacuation shelters that were intersected with the hexagon of community evacuation shelters sites, might have the possibility that people use the formal evacuation shelters. As a result, about 35,6 % of community's evacuation shelter sites are intersected with formal evacuation shelters (Figure 19). The cut-out in right hand side of Figure 19 shows how community evacuation shelter sites intersected with the formal evacuation shelters (blue hexagon).

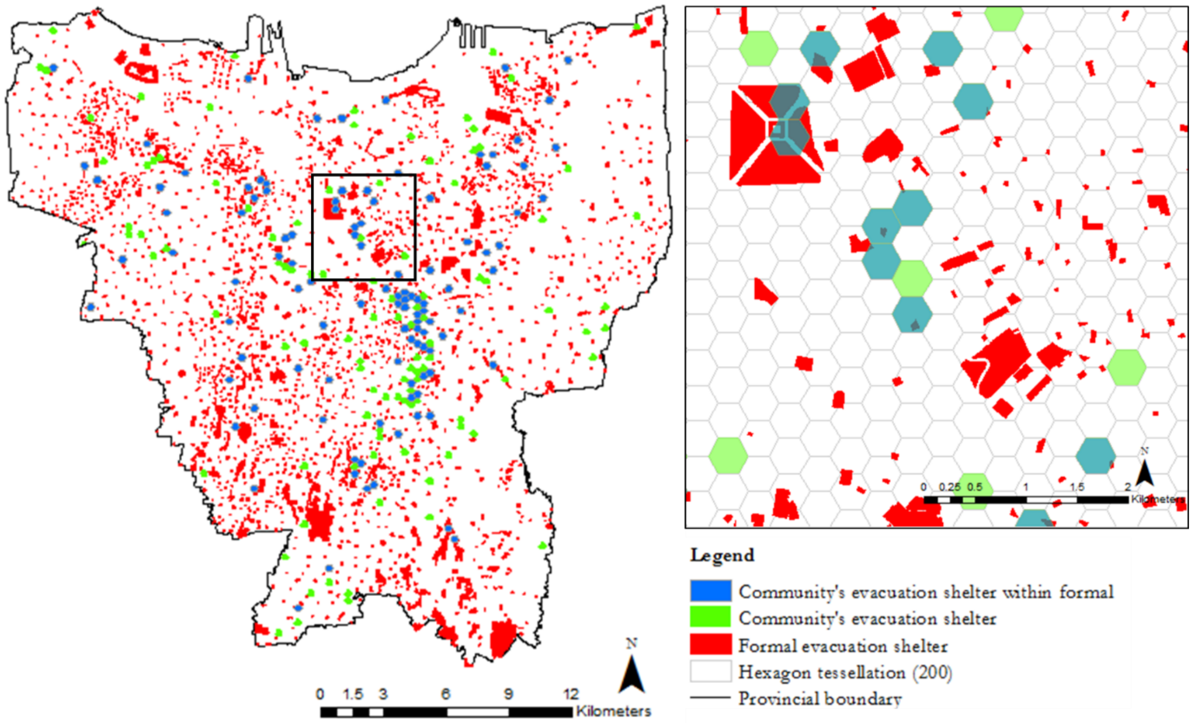


Figure 19 Community's Evacuation Shelter Sites within Formal Evacuation Shelters (Data: Jakarta City Planning Department (2014), Zook et al., (2016). Source: own analysis)

Based on the analysis above, we could determine the land use type of formal evacuation shelters that mostly used by the community. The result was the education facilities had much intersected with 53.5%. The green space was the second number with 29.6%. The rest are religious, health and sports facilities. Figure 20 shows the differences between each land use of community's evacuation shelter.

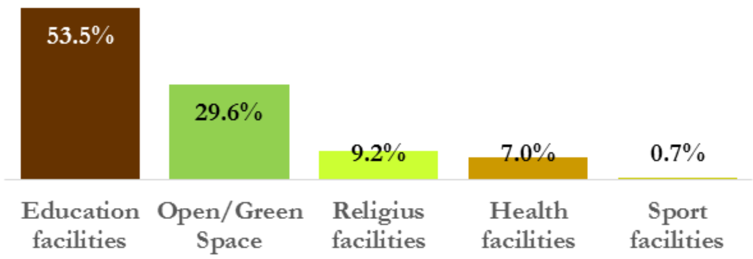


Figure 20 Land use type of formal evacuation shelter used by community (Data: Jakarta City Planning Department (2014). Source: own analysis)

Education facilities were used by the people in their daily activity. Therefore, people have more awareness of that location. Moreover, education facilities provided in every neighbourhood in Jakarta. About 2.700 public school and 4.100 private schools from all level were spread throughout the city (DKI Jakarta Province Government, 2015).

The assumption of the less use of formal evacuation shelter by the community much related to the people awareness. Based on the questionnaire (Appendix 2), all three respondents mentioned that they never use the formal evacuation shelter because they do not know the existence of it. One of them mentioned that formal evacuation shelters will be operated just after the flood event. Moreover, if no evacuation shelter, the respondent told that they prefer to go to their neighbour or family that safer than their house. It was much related to the familiarity of people with the location preferred. Two of the respondents mentioned that they often visit the location of evacuation shelter in their daily activities. One of them used as religious facilities and the other visiting his/her family.

4.2.2 Preferences on Topography, Drainage and Soil Conditions

The distance of evacuation shelter from the flood area is one of the criteria of evacuation shelter (ARC (American Red Cross), 2002; FEMA, 2015; Kar & Hodgson, 2008). If we calculate the mean distance of each community's evacuation shelter sites to the flood area, it gave result that the shelter sites mostly located inside the flood area. About 60% of community's evacuation shelter sites (hexagon) in Jakarta are within flood area (Figure 21). People looking for the nearest location from their own house was one of the possible reason. This, sometimes, makes the evacuee occupied the second floor of their neighbour houses near to their own house.

Kongsomsaksakul, Yang, and Chen (2005) mentioned that the ideal distance of evacuation shelter is outside flood area within 1 km distance. In the case of Jakarta, about 31% of community's evacuation shelter sites (hexagon) were outside the flood area but within the distance of 1 km. Based on the respondents answer (Appendix 2), the flood area was close and very close to the evacuation shelters that they used. It was between 200 m to 1 km.

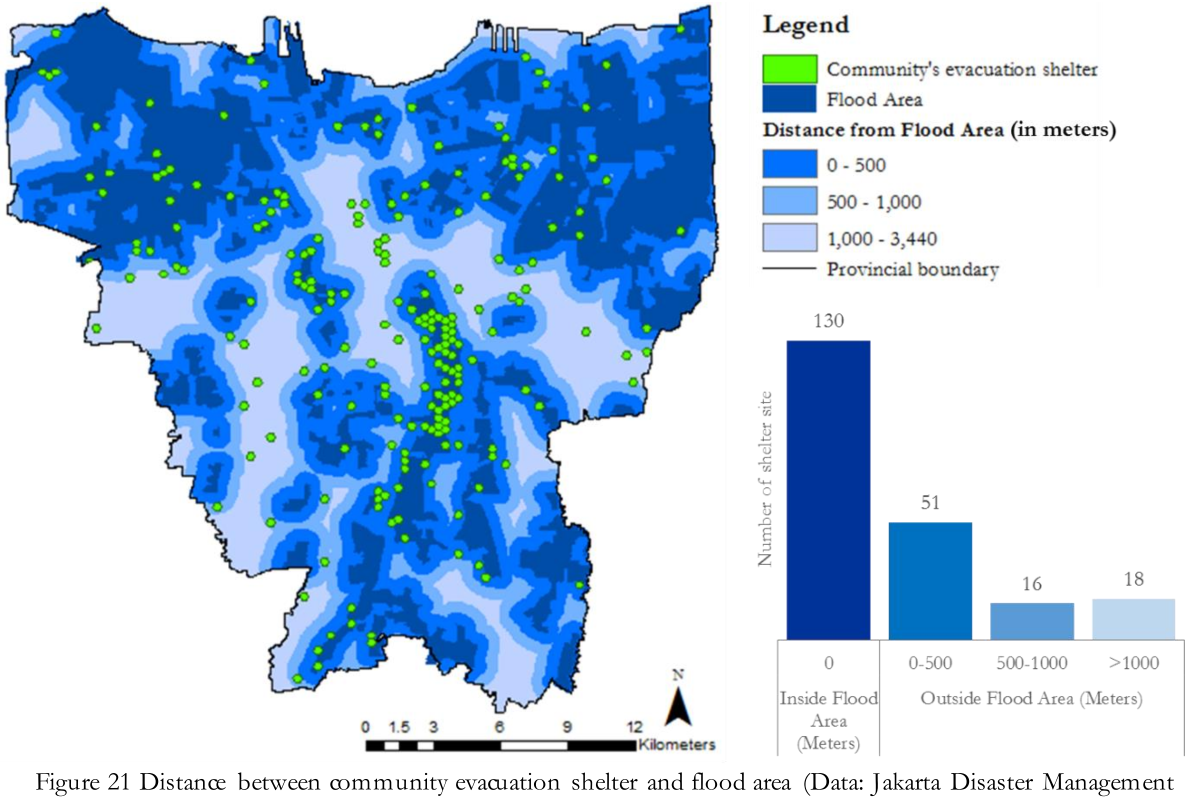


Figure 21 Distance between community evacuation shelter and flood area (Data: Jakarta Disaster Management Agency (2013/2015), Jakarta Planning Board (2002,2007), Zook et al. (2016). Source: own analysis)

4.2.3 Preferences on Accessibility

Respondents mentioned that the main reason they choose the evacuation shelters was the accessibility, safer from the flood area and proximity to their house. Accessibility, indeed as an important factor that considered by people when they should be evacuated (CCCMCluster, 2014; Tai, Lee, & Lin, 2010). One of the respondents added that the closer the evacuation shelters to their house makes them could monitor their house conditions at any time. Based on the questionnaire (Appendix 2), people mentioned that the evacuation shelters were very close, close and far with their house. The proximity to their house was between 200 to 300 meters. One respondent mentioned that location was 2 km far from his house. He added that the location shelter was the closer he could reach. The location was the religious facilities.

All the respondent mentioned that they reached the evacuation shelters by walk (please refer to Appendix 2). None of them are using car, motorbike or public transportation. This result was coherence with Chang and Liao (2014) in their research that people likely choose walk rather than driving. On the other hand, Kar and Hodgson (2008) assumed that people are usually using passenger cars to transport to the shelters. The type and impact of the flood influenced the mode preferences to reach the evacuation shelter. As an example was shown in Figure 14, based on one of the tweet text, that they use safety boat to reach the evacuation shelters. According to finding of this research, walking distance should be the main factor of consideration in planning evacuation shelter since the walk was preferred by people in Jakarta.

4.2.4 Preferences on Availability of Facilities

Facilities were one of the important factors that should be provided in each evacuation shelters (CCCMCluster, 2014). Based on the evacuation shelters used by the respondent (questionnaire result in Appendix 2), all location provide water facilities. The water was in good condition. The other facilities mentioned by two of the respondent was drainage, waste and electricity. All those facilities mentioned that the conditions were between less enough to very good. Electricity mentioned by the respondent was the less in term of the condition.

4.2.5 Preferences on Land Use Type

The land use type of community's evacuation shelter could be identified by overlaid the shelters with the land use map (please refer to Appendix 7). We could not claim that the location was exactly on particular land use type since the spatial unit was the hexagon. One hexagon may contain several type of land uses. This analysis could only give an overview in general on the type of land use that community's preferred as the evacuation shelters.

As a result, the land use of community's evacuation shelters was mostly on the green/open space. These land use type was matched with formal evacuation shelters provided by the government. The second most preferred was the residential land use. People tend to find evacuation shelter that near to their house and provided by their neighbours/ families. Based on several the volunteer tweets, there were relations with it. The volunteers provided their house as a temporary shelters for their neighbours whose house are flooded. Another type of land use was the offices. The office were the third land use mainly chosen by the community. From twitter text, several shelters used the basement of the office buildings that was flood free. Figure 22 shows the land use type of community's evacuation shelters.

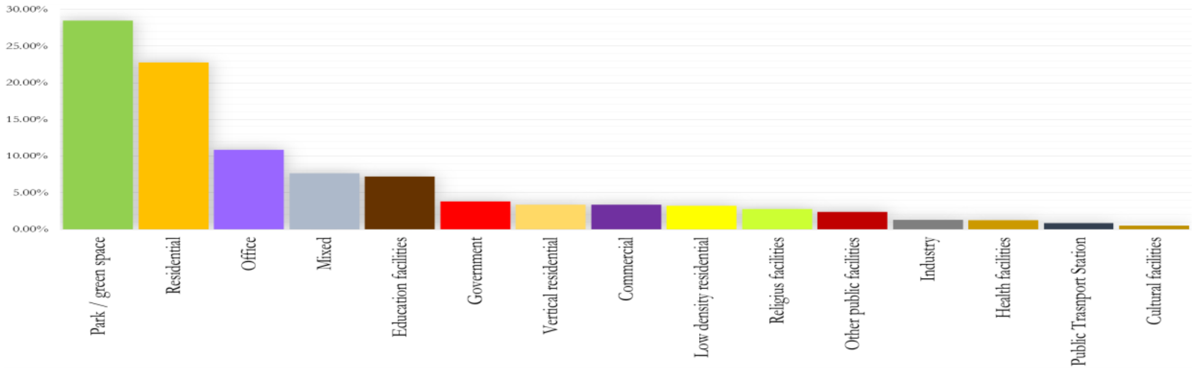


Figure 22 Land use type of community's evacuation shelter (Data: Jakarta City Planning Department (2014). Source: own analysis)

Some of the locations were used the tent as evacuation shelters instead of permanent building. One of the examples was the central evacuation shelters in Jakarta. This evacuation shelter was arranged in one of the largest green/open space in Jakarta. The government built the tent in the middle of the central park as a logistic centre and coordination centre (Figure 23). Another example was the shelter at the train station facilities. The evacuation shelter was formed by the tent in the park besides the railway. This area actually as the buffer area of the railway. According to picture shared by people on their twitter, so called tweet picture, the example of evacuation shelter land use types shown in Figure 23.

<table>
<tr><th>Land Use</th><th>Tweet Pic</th><th>Land Use</th><th>Tweet Pic</th></tr>
<tr><td rowspan="2">Park/ Green space</td><td></td><td>Sport Facilities</td><td>
</td></tr>
<tr><td></td><td>Station Facilities</td><td></td></tr>
</table>

Land Use	Tweet Pic	Land Use	Tweet Pic
Residential		Religious Facilities	
Office		Commercial	
Mixed Used (Apartment, Shopping Mall, Offices, SoHo)		Government Office	

Figure 23 Tweet picture of community's evacuation shelter (www.twitter.com)

4.3 Site Suitability of Evacuation Shelters Preferred by The Community Using Criteria Of Local Experts

4.3.1 Assessment Criteria of Evacuation Shelters

According to the literature review (sub-chapter 2.1), from 8 categories and 19 criteria, 11 criteria were selected by the local expert (please refer to Appendix 3). All categories were agreed by all the experts, although each category has different criteria selection. Local characteristic has influenced the selection of criteria of evacuation shelter suitability sites. Those characteristic such as the type of hazard, social characteristic of the population and also government finance were the most influencing factor in selecting criteria. All those criteria used to assess the evacuation shelter sites (hexagon) in Jakarta.

Different background of expert also influenced their choices on criteria. In this case, two type of expert were identified, urban planner and disaster risk expert. Urban planner mostly mentioned criteria related to spatial factors such as land use and security and protection. On the other hand, disaster risk expert focusing on accessibility, facilities and capacity which more related to emergency support. Figure 24 shows selected criteria by the local expert.

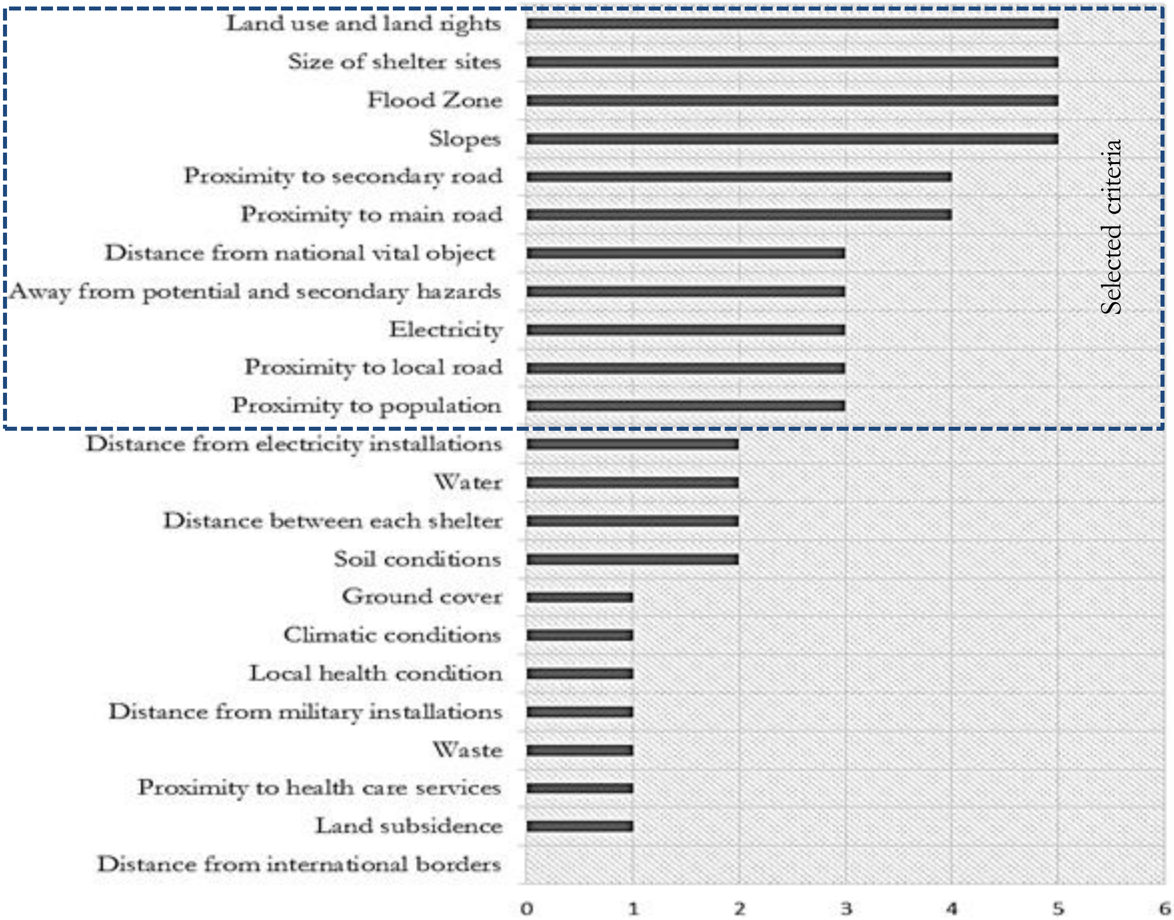


Figure 24 Selected suitability of evacuation shelter criteria by the local expert (refer to Appendix 3)

The first category was Topography, Drainage and Soil Conditions. All expert had the same understanding where slopes and flood zone need to be considered. The suitable area as evacuation shelter was less than 5% of slopes and outside future flood zone or past flood by time series. The data of flood area was merged map of last 50 years flood cycle period, which occurred in 2002 and 2007 (Figure 25 and 26), and two last flood event in 2013 to 2015 (Figure 27 and 28). Based on the interviewed, some of the experts mentioned that the most proper way to assess the suitability of flood area was using prediction of future flood map with cycle period of 50 to 100 years. The limitation in this research was the difficulties to obtained data of flood modelling. By using the last flood event by time series, it could substitute the flood modelling map.

There was a limitation related to the data in this research. The flood area map in 2013 to 2015 was the aggregation of the neighbourhood boundary. Means that if one spot area in one neighbourhood occurred by flood, all neighbourhood determined as flood area. It was influencing the analysis of suitability since the location identified based on Twitter dataset mostly located inside flood area. In 2002 and 2007 flood events, there were 50,6% and 54,8% of evacuation shelter sites were within flood area. The highest number of shelter within flood was in 2013/2014 with 60,4%. The lowest was in 2014/2015 with only 30,3% shelter inside flood area. This number closely related to the extent of flood in each year.

Another criteria of the topography category was the slopes. The slopes in Jakarta relatively flat, less than 5%, except several areas in southern part which have higher contour (Figure 29). The slope was also higher than 5% in the river area. By applied spatial join between evacuation shelter site and slopes map, all the shelter sites were located in less than 5% slopes.

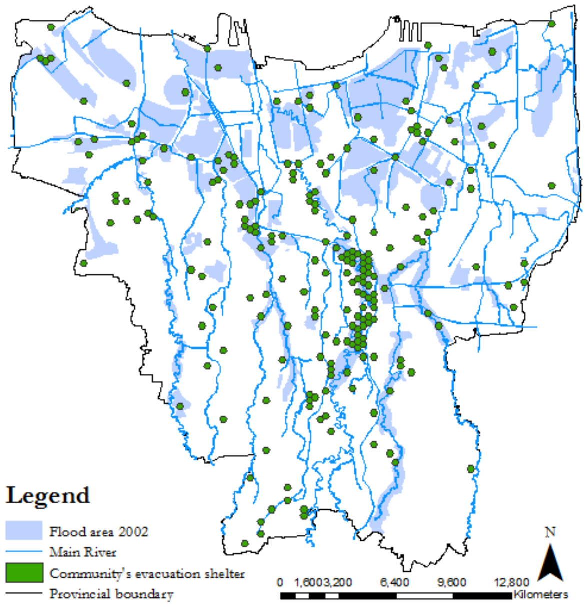


Figure 25 Flood area in 2002 (Data: Jakarta Planning Board (2002). Source: own analysis)

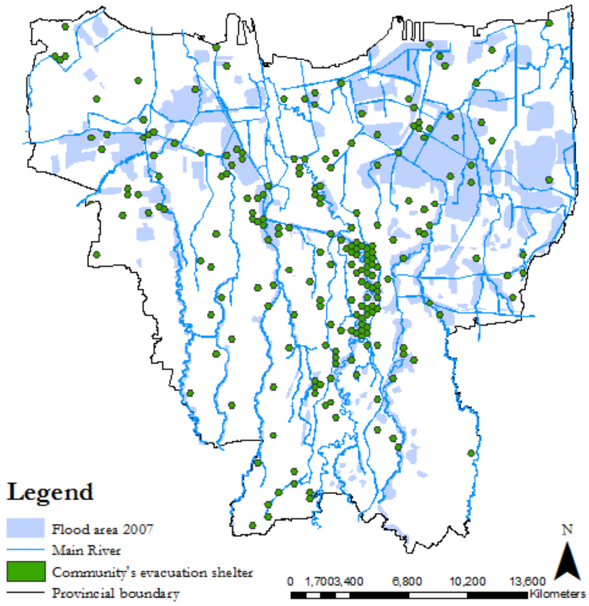


Figure 26 Flood area in 2007 (Data: Jakarta Planning Board (2007). Source: own analysis)

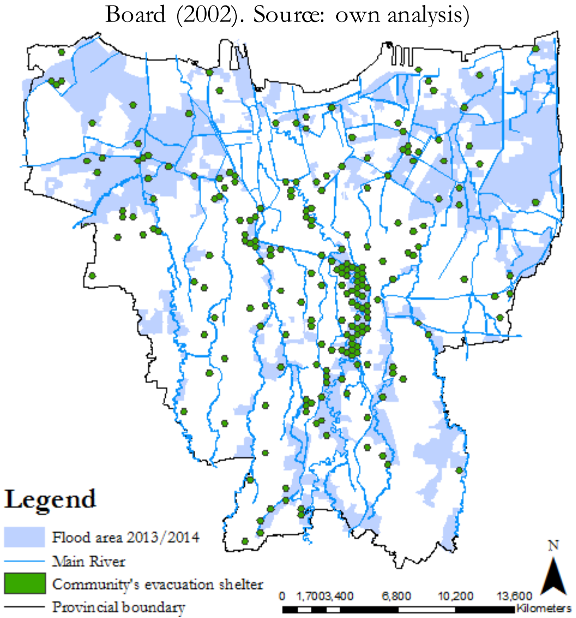


Figure 27 Flood area in 2013/2014 (Data: Jakarta Disaster Management Agency (2013/2014). Source: own analysis)

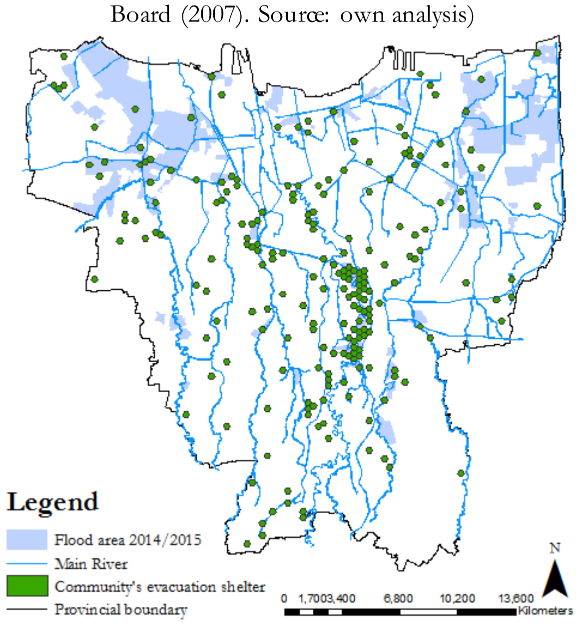


Figure 28 Flood area in 2014/2015 (Data: Jakarta Disaster Management Agency (2014/2015). Source: own analysis)

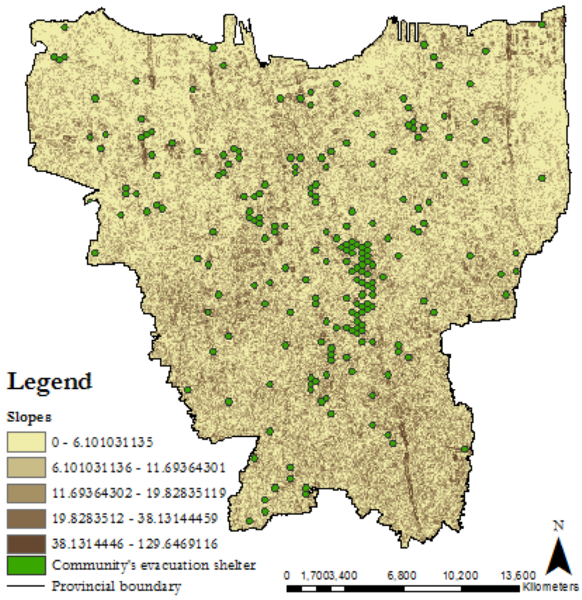


Figure 29 Slopes in Percentages (Data: Open DEM (2015). Source: own analysis)

The second category was the accessibility. In this research, accessibility related to the proximity to the evacuation shelters (Kar & Hodgson, 2008). People tend to evacuate to the location which had easy access to the evacuation road. In term of accessibility in Jakarta, proximity to the main road, secondary road and local road were the criteria chosen. The proximity related to the nearest evacuation shelter to those type of road was more suitable. The location should be accessible so that emergency car could easily reach the location to distribute logistic from the logistic centre.

Other criteria was the proximity from the population. Three local experts focusing on criteria that evacuation shelters should be located in the middle of the residential area. Since Jakarta has the slow-onset flood characteristic, which could inundated for 1-2 weeks, residential was the most risky than other area. Some of people were unable to return to their home for long period. Therefore, the shelters within residential area more considered than other area. Approximately 89,3% of shelter site was intersected with residential area.

Access to the health care was not part of the criteria chosen because health facilities should provide in each shelter as mobile facilities. Figure 30, 31 and 32 shows each level of the road in Jakarta and Figure 33 shows the residential areas.

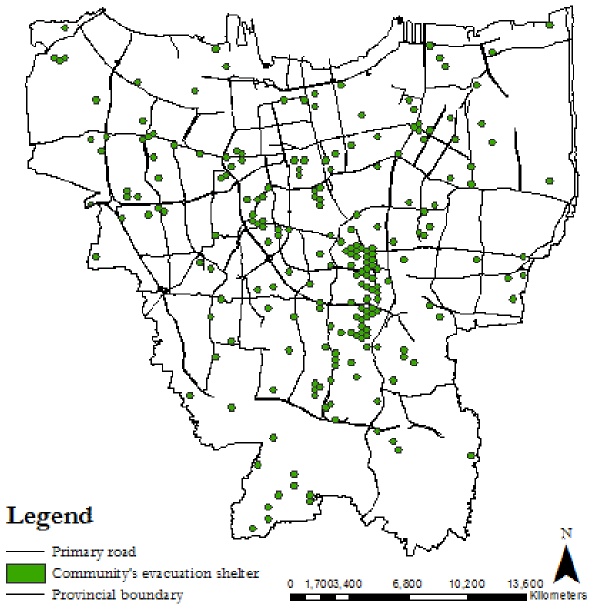


Figure 30 Primary road (Data: Jakarta City Planning Department (2014). Source: own analysis)

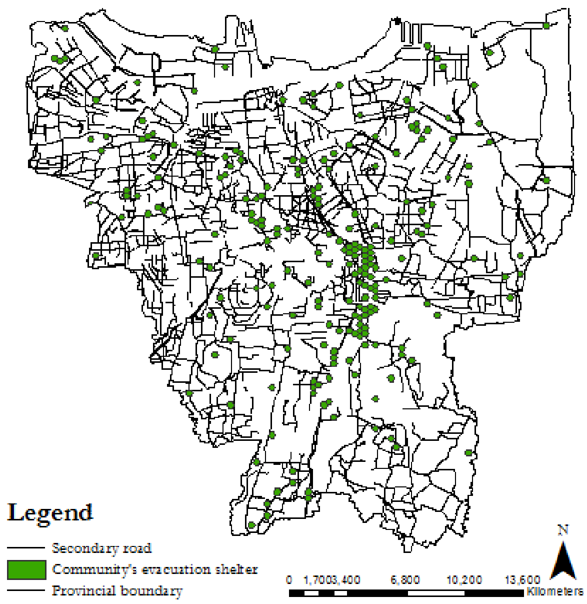


Figure 31 Secondary road (Data: Jakarta City Planning Department (2014). Source: own analysis)

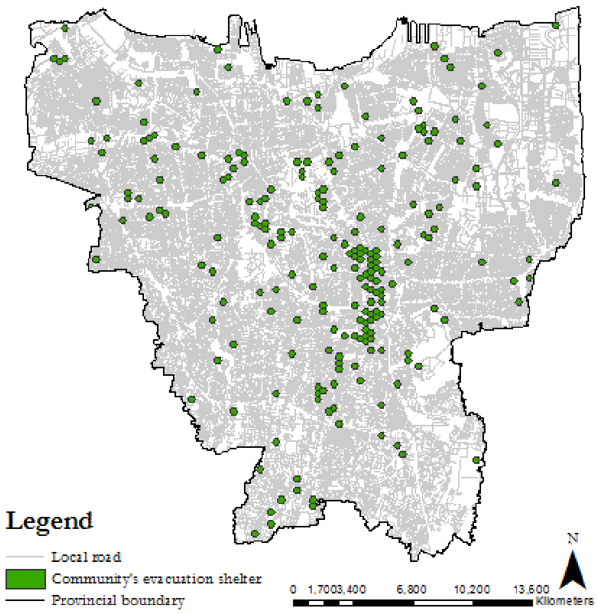


Figure 32 Local road (Data: Jakarta City Planning Department (2014). Source: own analysis)

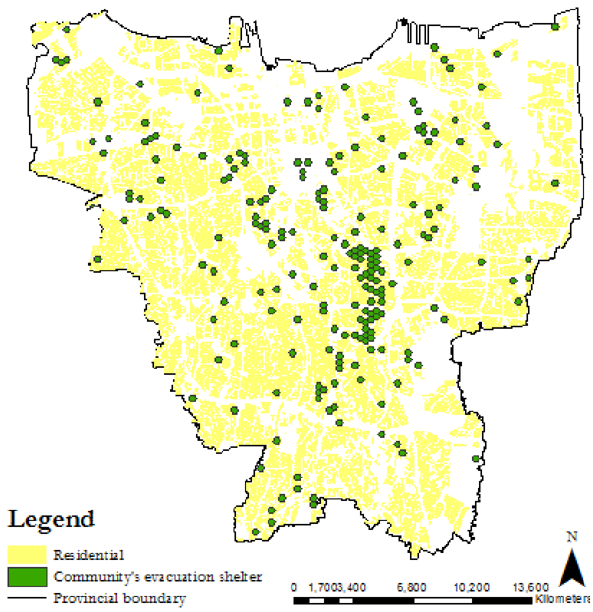


Figure 33 Residential area (Data: Jakarta City Planning Department (2014). Source: own analysis)

Availability of facilities category represented only by electricity criteria that tend to be critical. Most of the expert noticed that other facilities such as water, waste and toilet could be provided as mobile facilities, but the electricity was the most important. The importance of the electricity mentioned as the basic facilities should be provided in each evacuation shelters. The evacuation shelters should be near to neighbourhood electricity stations.

The data of power station in neighbourhood unit was unsuccessfully accessed. The data was only in provincial scale (Figure 34). The data of neighbourhood distribution could be substituted by the assumptions that all the buildings in Jakarta have already accessed by electricity with electrification ratio of 99.5% in 2015 (Ministry of Energy and Mineral Resources of Republic of Indonesia (in Bahasa), 2010). According to the assumptions, we can analyse those locations are provided by electricity. There were 26% of evacuation shelter sites in the buffer of 1 km from provincial power stations.

Moreover, there is another factor should be concerned about. Stated by the national electricity company in Indonesia, PT PLN (Persero) (2015), to protect customer in Jakarta, there are several conditions that oblige the company to shut the electricity, which was: the distribution station was flooded or the customer area was flooded or both are flooded and the power station was flooded. These factors should also be our consideration related to facilities suitability. The location outside flood area has the possibility to not be shut down.

Category of land use, building code and land right selected by all the expert. The shelter should be located on the public land so that the government could easily take control of it. The public land uses such as public green space, government building, sports hall, public healthcare, and school (UNHCR, 2007). There were 96,7% of evacuation shelter site that intersected with government owned land use. Figure 34 shows the distributions of land use owned by the government.

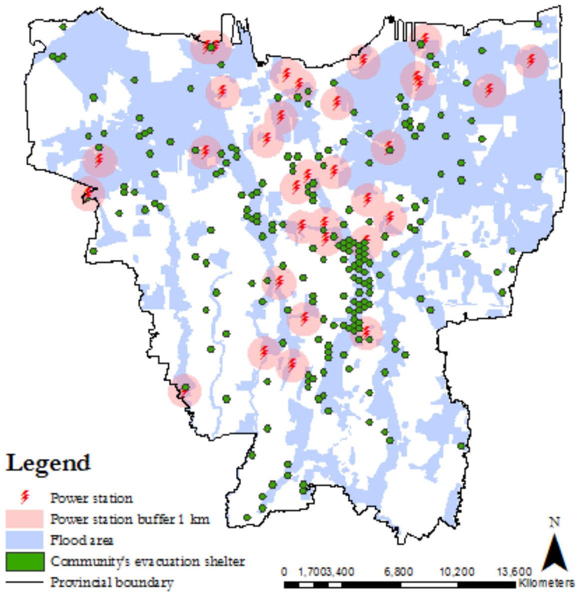


Figure 34 Distribution of electrical facilities (Data: Jakarta Disaster Management Agency (2013/2015), Jakarta Planning Board (2002,2007), Jakarta City Planning Department (2014). Source: own analysis)

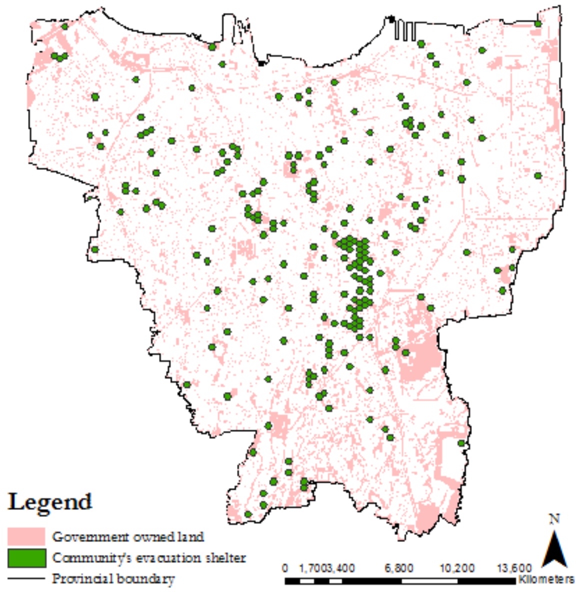


Figure 35 Land use owned by government (Data: Jakarta City Planning Department (2014). Source: own analysis)

The criteria for security and protection category were away from potential and secondary hazards (Figure 36 and 37). The location should be located far from hazardous facilities such as industrial. Distance from the national vital object should be recognized. This criterion not mentioned in any reference but most local expert considered it. The national vital objects were location/building/installation in which economically strategic and set by the regulation.

The national vital object includes the objects of national defence, energy and tourism. It should be considered since those objects were driven national economic and national security. Jakarta as the capital city of Indonesia had many national vital objects, which if the objects were interrupted, the national security could also influence.

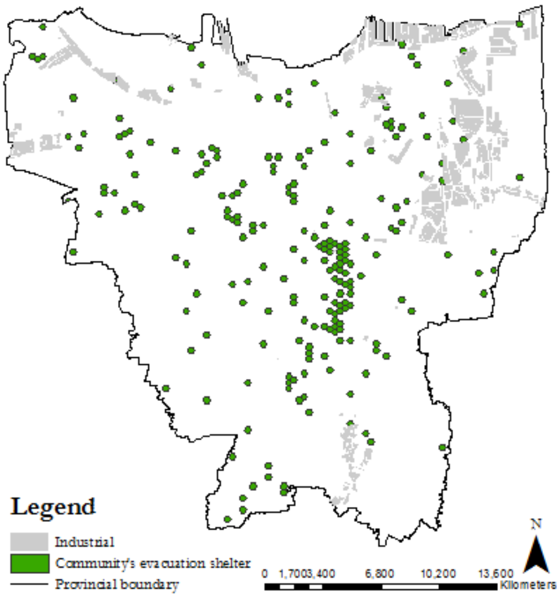


Figure 36 Potential and secondary hazard (Data: Jakarta City Planning Department (2014). Source: own analysis)

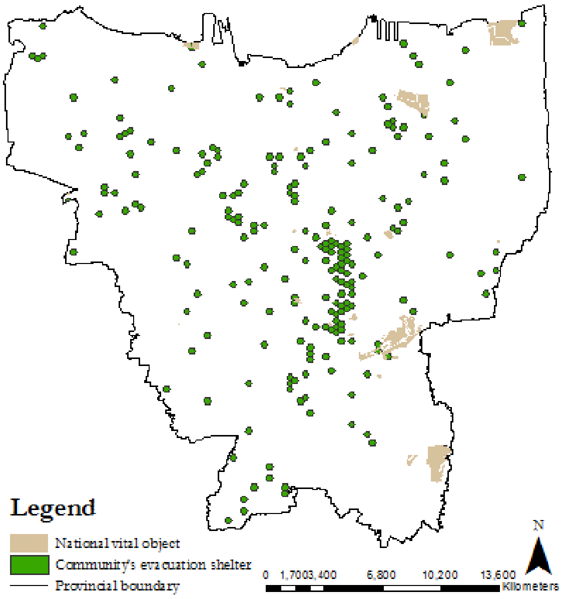


Figure 37 National vita object (Data: Jakarta City Planning Department (2014). Source: own analysis)

Another category was the capacity category. This category related to the size of the shelter which agreed by the local expert should have approximately 3 m2 per person without facilities. This was the minimal space as a sleeping area for a person. The parameter mentioned by most of the expert as follow Indonesia emergency regulations. However, since the accuracy assessment of twitter dataset showed that there was difference distance between geolocation and location, affected on the spatial unit that could not too detail. By using hexagon of 200 meters, there was a limitation to analyse site suitability, especially the capacity. The capacity could only be measured in land use or building unit, therefore, in this case, capacity criteria was omitted.

4.3.2 Criteria Weighted of Evacuation Shelters Sites Suitability

The final criteria chosen by the experts was given weighted based on their importance. The weighted given for every category and criteria within the category. As a result, the category of accessibility and capacity was the most important from others (Figure 38). As stated in the literature review, accessibility and capacity also the mentioned by most literature. In this research, since the capacity was omitted, the weight for the capacity category was equally distributed among other categories.

In contrarily, the local experts thought that topography, drainage and soil conditions take the last importance of all category. Even most literature mentioned that the location outside flood area is the most important, but it was not that important in Jakarta. It was related to the characteristic of the flood in Jakarta, where flood area extended throughout the city. Some location of flood area also remained difference each year. From the map of flood area in 2007 to 2015, some locations are yearly flooded, but others seem changed.

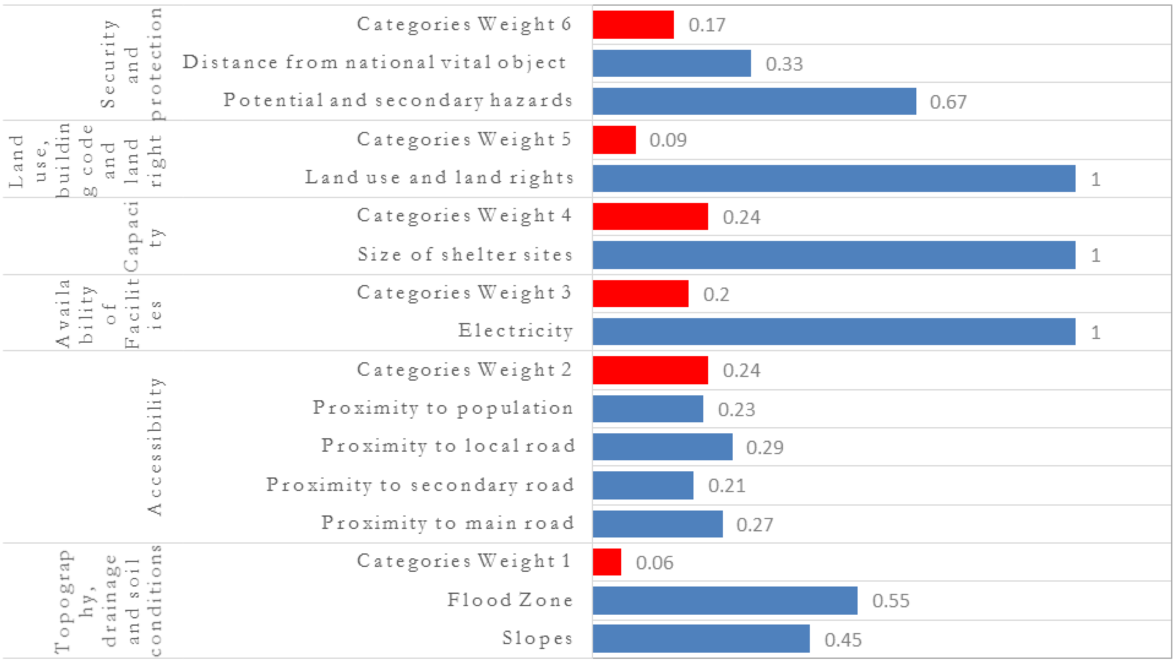


Figure 38 Weight of the category and criteria (refer to Appendix 4)

4.3.3 Sites Suitability of The Community Evacuation Shelters

Evacuation shelter site suitability was measured by several category and criteria. Each category was performed to identify the suitability of community's evacuation shelter. Here, we integrated the category, criteria and weight chosen by the local expert with the evacuation shelter sites (hexagon) preferred by the community based on twitter dataset. Each category become an assessment for the sites suitability and concluded in the composite index as a result.

The first category was the topography, drainage and soil conditions, which represented by flood area and slope criteria. We measured the flood area criteria using overlap formula. The more the sites outside the flood area, the more suitable the sites was. The formulation was considered the limitation of the flood map data, which was aggregated data. Thus, the formulation of the criteria was not the restriction that the site should be suitable if outside the flood area. The second criteria were the slope. At the beginning of the analysis, we had set the map of the area within 5% slope. That map became an input in community viz with formulation: the higher the site overlap, the higher the score was. Figure 39 shows the setup of suitability measurement of topography category.

Second, the accessibility category. This category conducted with criteria of proximity to the main road, secondary road, local road and to population (within the residential area). As seen in Figure 40, formulation related to the main, secondary and local road was set using proximity. A higher score was calculated for the site that is closer to those type of road. The analysis of accessibility to the road was not detailed since the area was not building site. The population criteria were measured by the location within the residential area. The more a site overlap with the residential area, the higher score of suitability.

Category of the facility was the third. Based on local expert, the category was described by electricity facility. Two measurements were conducted in electricity criteria. First, the closest evacuation shelter site with the power station within the buffer of 1 km. The formula to obtain the measurement was overlap, the score was higher if the site overlap with the buffer area. The second was the using the assumption that all the buildings in Jakarta have facilitated with the electricity. However, based on PT PLN (Persero) (2015), the electricity of the location within flood area will have the possibility to be turned off. This assumption brought to a formulation that the more site overlap with flood area, the less score of suitability was (Figure 41).

Another category was the land use, building code and land right. The criteria included in this category was the land uses that owned by the government. Land uses that categorized as owned by the government was the public open spaces, the government offices, the public facilities (e.g. school, health facilities and station). The more community evacuation shelter sites overlap with those land use the higher the score of suitability (Figure 42).

The last category mentioned by the local expert was the security and protection. The criteria for this category: far from the secondary hazard (industry) and vital object. As the formulation, proximity setup tend to be fitted. The sites which far from the secondary hazard and vital object would have a higher score of suitability (Figure 43).

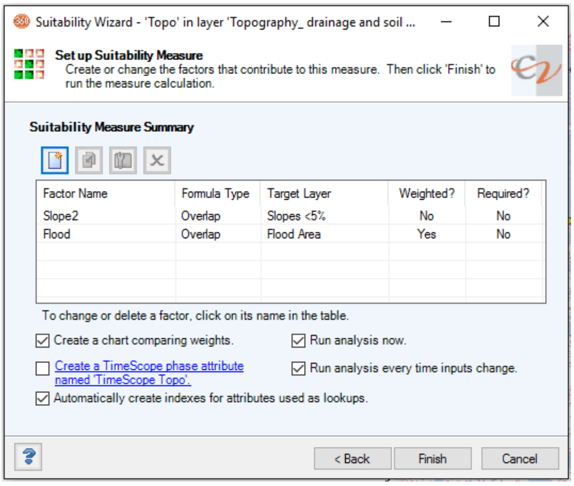


Figure 39 Set up suitability measure of topography, drainage and soil condition

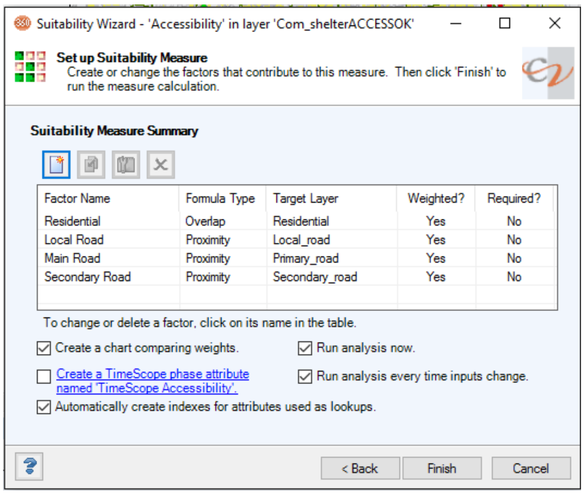


Figure 40 Set up suitability measure of accessibility

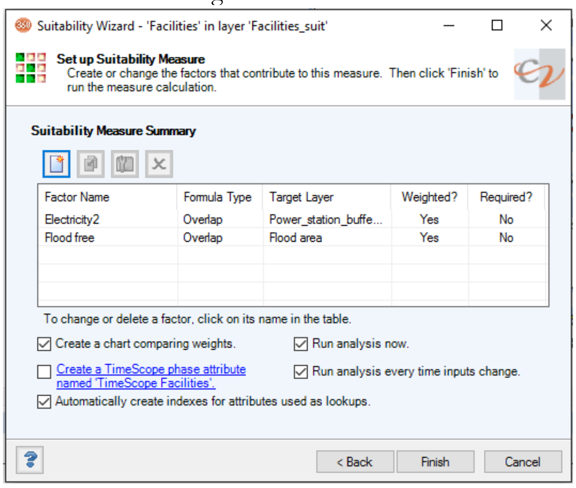


Figure 41 Set up suitability measure of availability of facility

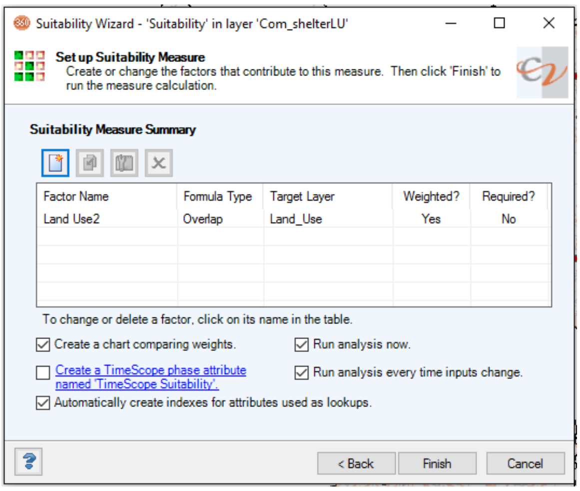


Figure 42 Set up suitability measure of land use, building code and land right

Furthermore, since classification of shelter sites suitability score was not defined by the expert, data classification method should be carried out to determined class boundaries. According to the result of the measurement above, each category of suitability should be classified based on their suitability score distribution. The graph of topography, drainage and soil suitability shows that the data distribution was linear (Figure 44). Based on (Kraak & Ormeling, 2010), the most suited method for those type of curve was

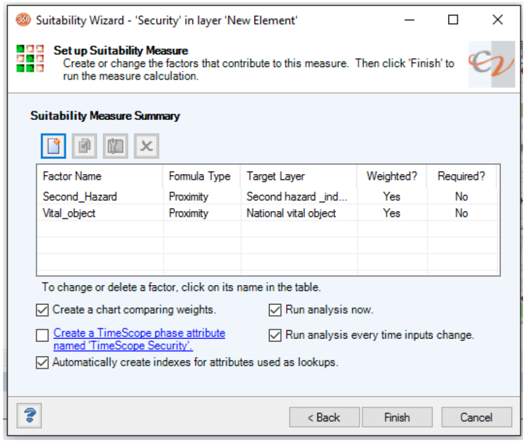


Figure 43 Set up suitability measure of security and protection

equal interval or standard deviations. The curves of accessibility (Figure 45) shows the type of normal, therefore equal interval classification method was conducted.

The three other category have the same pattern of curves, which more or less lead to arithmetic and geometric curves (Figure 46, 47 and 48). The most proper classification type for those were systematically changing class intervals. In ArcGIS, geometric series provided for those classification method type. Thus, the category of availability of the facility; land use, building code and land right and security and protection were suited with geometric series.

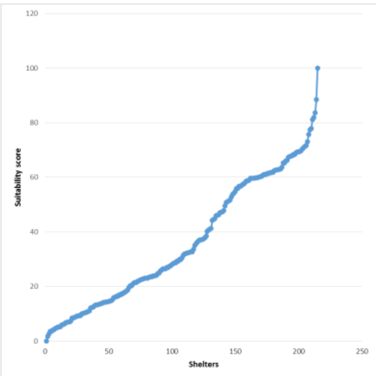


Figure 44 Curve of topography, drainage and soil condition suitability data distribution

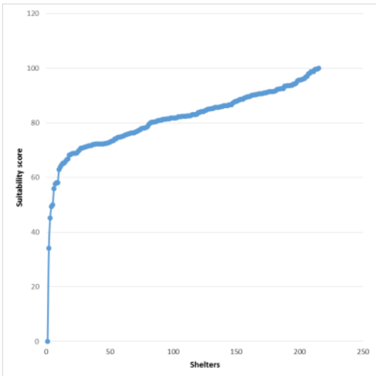


Figure 45 Curve of accessibility suitability data distribution

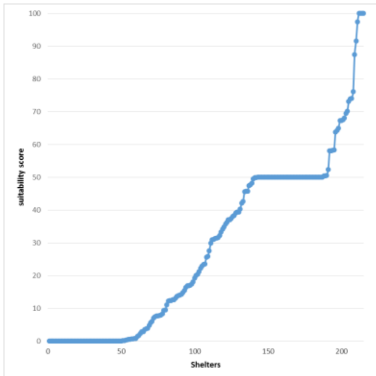


Figure 46 Curve of availability of facilities suitability data distribution

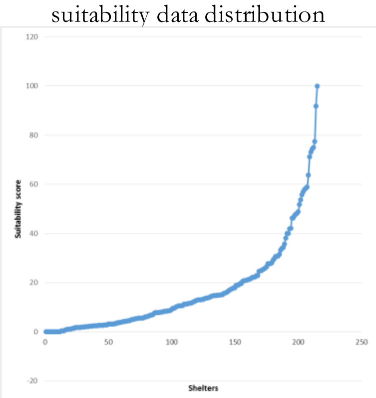


Figure 47 Curve of land use, building code and land right suitability data distribution

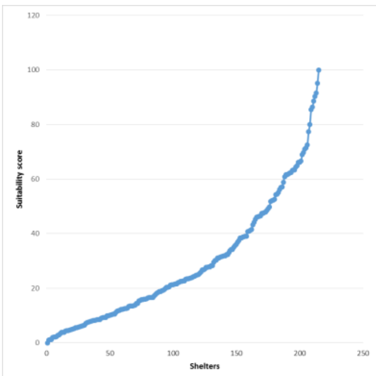


Figure 48 Curve of security and protection suitability data distribution

As a result, the topography, drainage and soil condition had a highest number of low suitability (Figure 49). There was 116 sites of community evacuation shelter in this class and only 24 sites was in high suitable. This tendency of the data influenced by the limitation of flood map data, which was the aggregation of each neighbourhood area. The site might be not located in a flood area, but another area in the same neighbourhood was flooded then all neighbourhood identified as flood area. The site that had low suitable was clustered in the centre of Jakarta. This area was river catchment area that has high slope percentage.

Another category which had the highest number of low suitability was the availability of the facility (Figure 51). About 118 sites of evacuation shelter determined as low suitable. The topography and facility category nearly have the same pattern of suitability since both were using the same criteria which are flood area. Sites in flood area have less suitability in electricity facility. For security reason, all neighbourhood and power plan that are flooded, the electricity should be turned off. Moreover, based on several local expert, the facility could be excluded in suitability analysis. In the case of Jakarta, where the economic condition and government budgeting was high, all the facility (e.g. electricity, healthcare, water) could be provided as moving facilities in every evacuation shelter.

In contrast with topography and facilities category, accessibility has most high suitable site of community evacuation shelter (Figure 50). More than 90% of the site in high suitable location and only 1 site was low suitable. The area in Jakarta mostly accessed by road from main to local road. Even in the small and low-income residential, the road was accessed by. The score of accessibility mainly gave from "within residential" criteria.

Most of the evacuation shelter site mentioned in twitter dataset were located in residential area, thus, it increasing the score of suitability. Corsellis and Vitale (2005) mentioned that evacuation shelter should be located as close as the evacuee house. Based on questionnaire people also mentioned that the location that they choose were the one that nearest to their house. Security of the house and easiness to check the house conditions was the reason behind.

In the side of land use, building code and land right category, 99 sites of evacuation shelter classified as medium suitable. The low and high suitable sites have an equal number. As shown in Figure 52, Kampung Pulo neighbourhood has more medium and low suitable than highly suitable. This area was also owned by the government but restrictedly to be developed since it was the catchment area of the main river in Jakarta.

If we look at the security and protection category (Figure 53), there was a pattern of suitability distribution. Most of the industrial and military zone in Jakarta distributed on the eastern side. This generates the suitability of evacuation shelter site on the east side became less suitable. In central Jakarta, there was president house. Based on national vital object regulation in Indonesia, the presidential house should be clear from a potential threat.

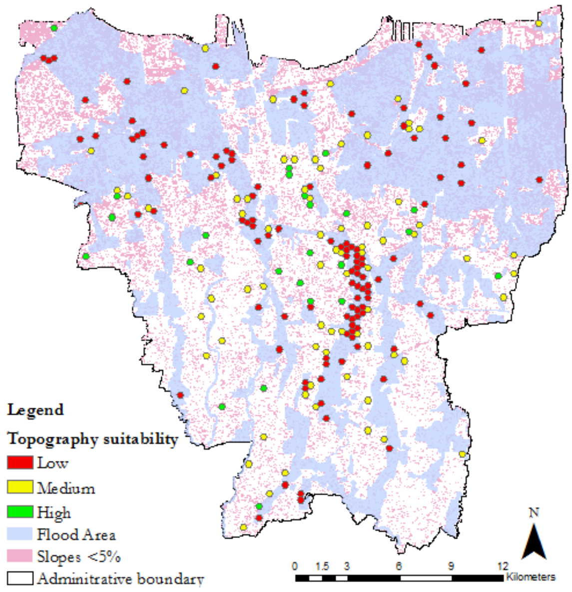


Figure 49 Suitability map of topography, drainage and soil condition

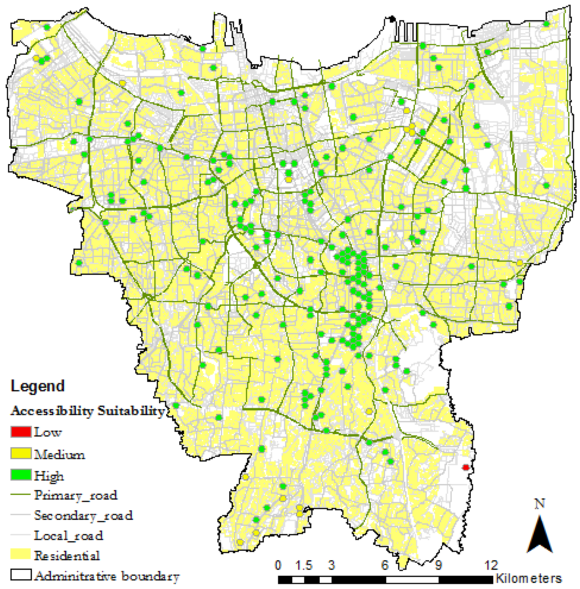


Figure 50 Suitability map of accessibility

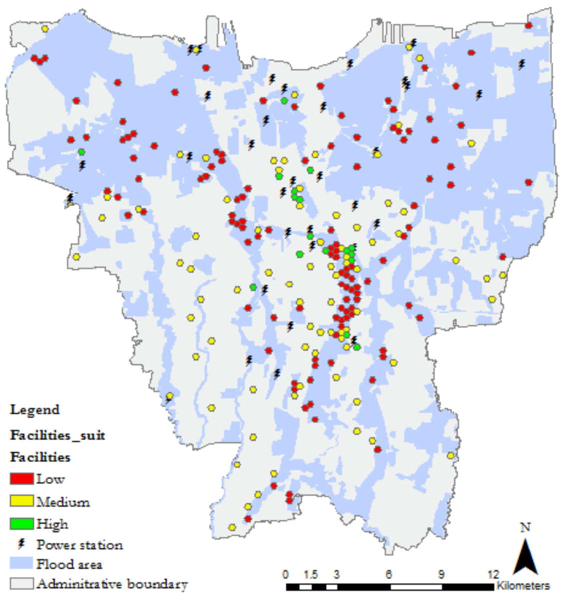


Figure 51 Suitability map of facility

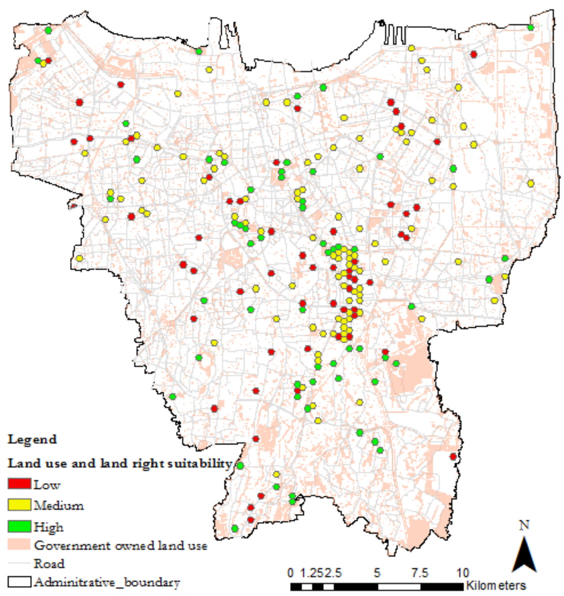


Figure 52 Suitability map of land use, building code and land right

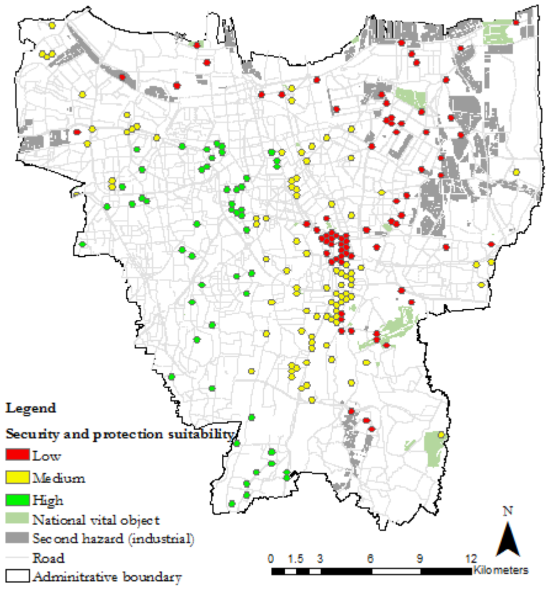


Figure 53 Suitability map of security and protection

The composite index map that combined all category of suitability shows in Figure 54. In this research, the suitability analysis was only to determine how the pattern of community evacuation shelter suitability was. Which criteria that were not meet the suitability based on the local expert criteria, as the result of the analysis.

To generate suitability composite index map, suitability score of each category was classified with number: Low = 1, Medium = 2 and High = 3. Using the scoring as mentioned before, could avoid different class in different score. For instance, the low suitable in topography will also indicated as low in the composite index calculation.

In determining the class boundaries, the mathematical approach that depends on the type of data distribution was conducted (Kraak & Ormeling, 2010). The data distribution of composite suitability score shows the type of linear curve. Thus the classification method was used equal interval of 3 classes.

The overall result of community evacuation shelter site suitability shows that the locations mostly in medium suitability class. About 127 sites were determined as medium suitable. Suitability pattern shows that the high suitable was dispersed throughout the city and mainly on the west side of Jakarta.

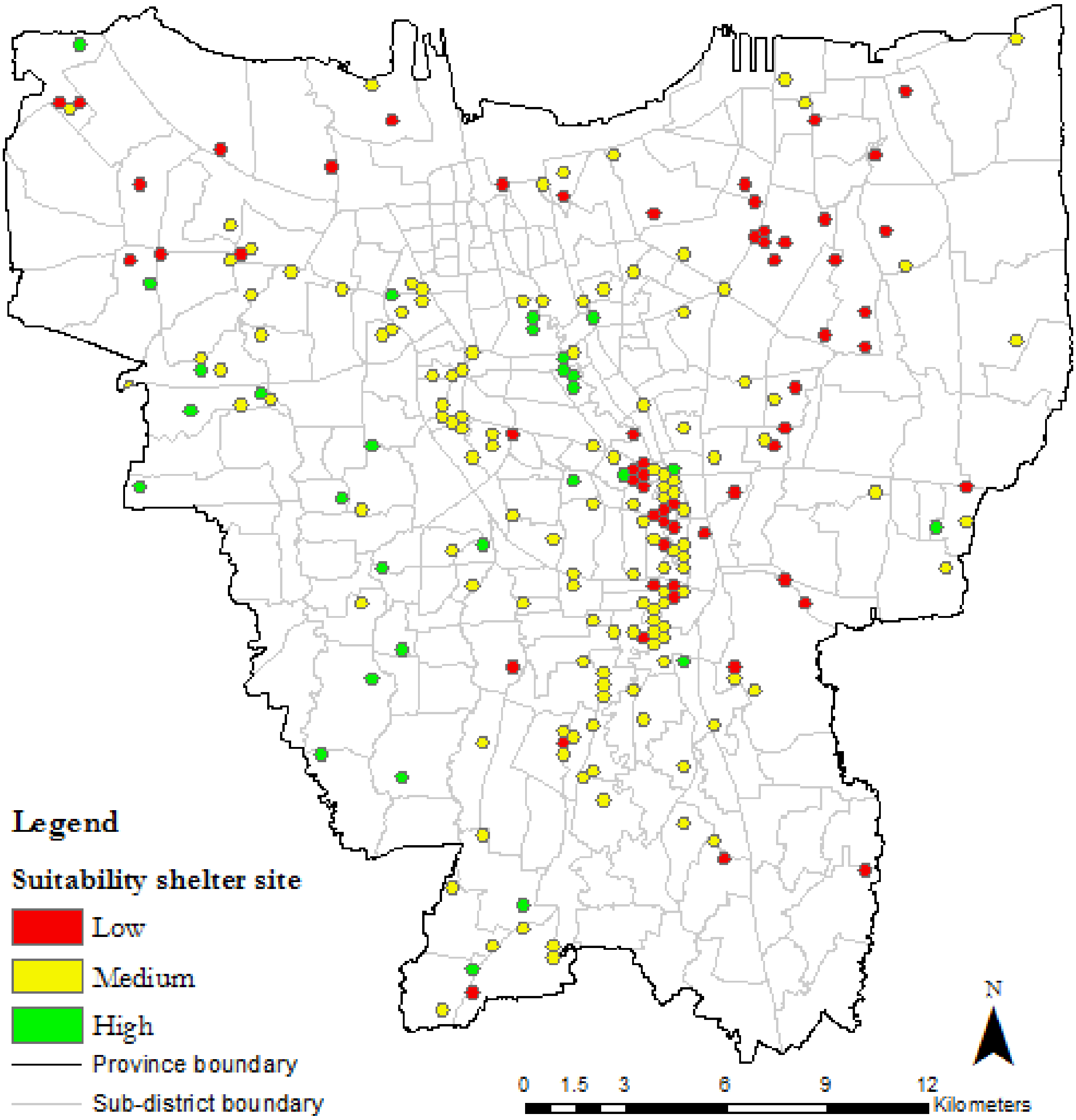
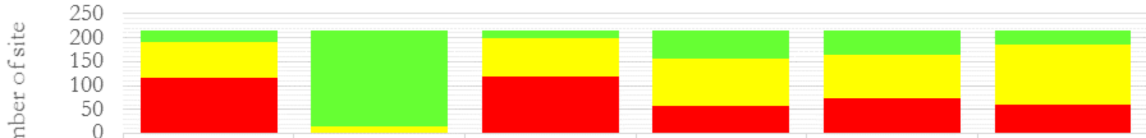


Figure 54 Community evacuation shelter site suitability



	Topography	Accessibility	Facilities	Land use	Security	Composite Index
High	24	200	17	58	51	29
Medium	75	14	80	99	90	127
Low	116	1	118	58	74	59

Figure 55 Number of suitable site of each category/criteria

According to the result of sites suitability, there are relation between local expert criteria and community preferences based on VGI dataset (Table 5). The suitability ranking was based on the highest number of high suitable shelter sites in each category. For instance, the accessibility have 200 sites that classified as high suitable, then accessibility was considered as the first rank of suitability analysis. The logic behind it was if the shelter sites have more high suitable class in one of category, we might argue that these category representing the preferences of the community.

As a result, we could argue that accessibility was considered by both. Based on questionnaire, the shelters that near to their house was most preferred by the community. Local expert agreed by given the highest weight to accessibility category. People also seen not too worry if the location was near the flood area. As we can find that the category of topography had the most low suitability score.

Moreover, based on suitability analysis, land use and land right had more score on high suitability. Even it was not clearly stated by the respondents (questionnaire), but familiarity of the location related to land use was considered. Green space as a public land use and it was located in residential area was preferred more than the other land use.

Table 5 Summary of community preference and local expert criteria

Category	Criteria	Suitability Analysis	Local expert criteria (refer to Apapendix 4)	Community preferences (questionnaire and spatial pattern of twitter)
Topography, drainage and soil conditions	Flood area	4	5	Mostly inside flood area and within 1 km distance from flood
	Slope			
Accessibility	Proximity to main road	1	1	
	Proximity to secondary road			
	Proximity to local road			
	Proximity to population			Mentioned as the most important factor
Availability of Facilities	Electricity	5	2	Not spesified as concerned but the condition need to be improved
Land use, building code and land right	Land use and land rights	2	4	Green space and residential (related to familiarity concerned)
Security and protection	Away from potential and secondary hazards	3	3	
	Distance from national vital object			

Notes:
1 to 5: Very important to less important

4.3.4 Sensitivity Analysis

Conducting sensitivity analysis could give a better understanding of the robustness of suitability model. In this research, the sensitivity analysis operated by deleting some category. The category that was chosen to be deleted was the ones that less mentioned by the local expert. Based on local expert preferences, the category of facilities and security and service chosen by only 3 from 5 local experts. Another category was the one that had the highest number of low suitable sites, in this case, topography. Topography was related to flood area and slopes. In Jakarta, the characteristic of the flood was extended almost all the city and the slopes relatively less than 5%. This reason was brought debated to the local expert. If the flood area criteria included then there were less suitability of evacuation shelter in all Jakarta. That opinion also brings us to included topography category in sensitivity analysis. The weight for removed categories was distributed equally to another category.

As a result, by removing the category of facility and security and protection, Figure 56 shows that the number of the suitable sites increased from 69 to 91 sites. It was higher than by removing the category of topography (Figure 57). This might happened since the category of topography, drainage and soil conditions had the least weight compare to other. Moreover, by removing facilities and security category, the low suitable sites on the eastern side of Jakarta become medium and high.

According to Ligmann-Zielinska and Jankowski (2008), the model of shelter site suitability will change by deleting and adding some criteria. However, every changing give the same pattern of suitability class. Figure 58 shows that the medium suitability was always the highest for all conditions. Likewise, it was also shown for low and high suitability. The robustness of the suitability evacuation shelter site model much related to the uncertainty of criteria chosen by the local expert. If we reviewed the pairwise analysis in criteria/weight analysis, there were two experts with inconsistency rate above 0,2. This might give effect to the uncertainty of the model.

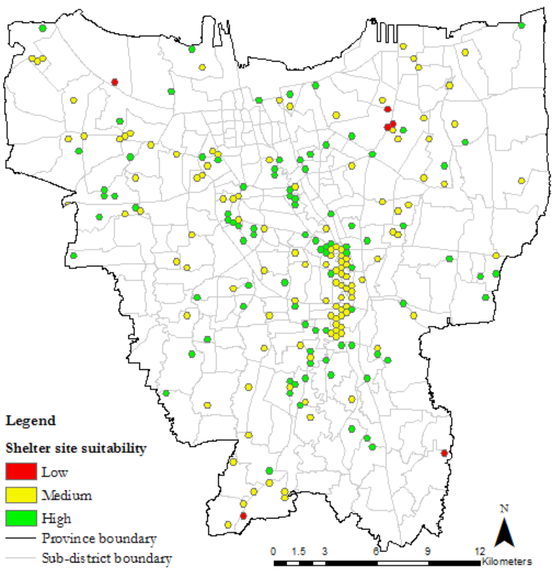


Figure 56 Sensitivity analysis by removed facilities and security category

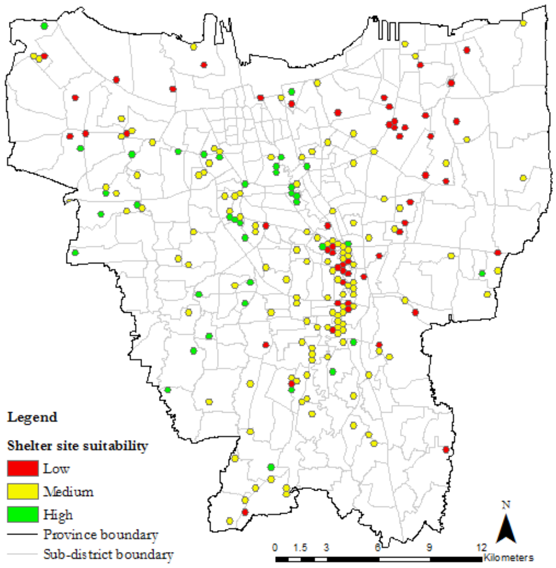
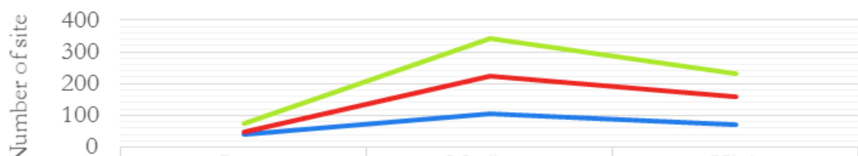


Figure 57 Sensitivity analysis by removed topography category



	Low	Medium	High
Sensitivity 2 (removed topography)	25	119	71
Sensitivity 1 (removed facilities and securities)	6	118	91
Base	42	104	69

Figure 58 Comparison of suitability site of sensitivity analysis

4.4 The Usefulness of VGI Data in Assessing Flood Evacuation Shelters by The Community

According to (Takahashi et al., 2015), Volunteered Geographic Information (VGI) has become a good media in giving information related to disaster planning and preparedness. In the case of Haiyan's typhoon, twitter, was a platform for shared information of evacuation centre. Further, in this research, VGI was used in more detailed on long term case of evacuation shelter planning.

In general, this research used VGI as the main data on discovered community preferences of an evacuation shelter. The twitter dataset, as the source, was adopted since it could give real-time information when the flood occurred. The information, in this case, was related to the location of evacuation shelter that had been used by the community in last flood event. Based on people who sent twitter information related to the evacuation shelter, the location was mapped. After getting the location of the shelter, those people, which identified as the evacuees, was asked for their feedback through the questionnaire. The questionnaire asking deeper information on their preference of specific evacuation shelter.

Moreover, the location of evacuation shelter based on twitter dataset was analysed their suitability. The purpose of this analysis was to integrating the location preferred by the community with criteria from the local expert. To analyse suitability, it closely depended on the spatial unit of the dataset. Therefore, on choosing the proper spatial unit, accuracy assessment of twitter dataset was conducted.

According to each step of evacuation shelter planning based on twitter dataset, there were benefits and drawbacks of using VGI as the main source of the dataset. Next chapter will give an overview of those benefits and drawbacks.

4.4.1 The Benefit on Using VGI in Assessing Site Suitability of Community Flood Evacuation Shelters

One of the most excellence of VGI mentioned by many researchers was the function of capturing real-time information. Erskine and Gregg (2012), on their research, explained that the benefit of real-time information could bring into the use of VGI to advanced real-time disaster mapping. Even though in this research does not depend on the real-time data, but the information of evacuation shelter during flood event was the main focus. As a result, the location of evacuation shelter that used by the evacuee when the flood occurred could be identified. Using VGI in evacuation shelter planning proved that this type of information could rely on captured general pattern of the location.

Moreover, this research provides provincial area of 662 km^2. The community preferences of evacuation shelters in this large coverage area, could be determined in relatively short time. By only using secondary data of VGI, we able to identified the distribution of evacuation shelters without conducting a field survey. Mentioned by Mooney, Sun, and Yan (2011), using traditional data collection, urban environment spatial information was time and cost consuming. Moreover, as their discussion, VGI could be an alternative to substitute traditional data collections.

Another benefit of using VGI, in the Twitter dataset, there was much information that could be captured, based on the purpose of the study. Through analysis of twitter content, found that there was various information related to the evacuation shelter. First, VGI could identify many types of the user based on the content of the tweet. In this research we could classified the user such as the volunteer, the governments, NGO's and the evacuee. The last user mentioned also became the respondent to get their feedback on preferences. Therefore, VGI was also a good platform to find the respondents as a sample of the population.

Second, according to the content, we also able to find the time frame of when people tweet based on the sentences. For instance, the present tenses. We could analyse the people who were in evacuation shelter at the time they sent to twitter. From those type of information, we could analyse the location in more accurate.

4.4.2 The Drawbacks on Using VGI in Assessing Site Suitability of Community Flood Evacuation Shelters

Besides benefits on the use of VGI, there were also several drawbacks. The problem of geographic accuracy was being an attentions of many researchers currently. This problem could be the main drawbacks of the VGI. Accuracy problem was also raised in this research. Based on accuracy assessment, there was a deviation between the geolocation supplied with the twitter data and the actual location mentioned within the content of twitter. There were many reasons behind. One of the possible reason was people tweeting while moving. There might give time interval until tweet was sent. Also, there were possibilities that people tend to send twitter after being away from the location. In their research, Poorthuis et al. (2014) argue that geotagging issue related to different levels of accuracy of technologies. The various type of GPS and WiFi also influenced the accuracy of geotagging.

The accuracy problems influenced the spatial unit to be analysed. In this research, since the suitability analysis was the end of the evacuation shelter plan, the proper spatial unit should be determined. From the analysis in chapter 4.1.2, we can concluded that VGI data could not be as an input for detail spatial unit analysis (e.g. building site unit). By considering that there was a gap of distance, using detail spatial unit seems to be risky. There will be a lot of bias in the calculation of suitability analysis. This would affect the final result of the suitability analysis.

Moreover, the spatial unit also affected on the criteria to be used in suitability site analysis. Since the spatial unit was not detailed (hexagon of 200 meters), capacity criteria could not be included. Capacity criteria were related to the calculation of how many people could be accommodated in one building of evacuation shelter. It would be too bias if the calculation using hexagon unit, which may contain numbers of building.

The VGI in evacuation shelter planning has also been used in getting feedback from targeted respondents. Based on the user analysis from twitter dataset, we could identify people who were the evacuee from the last flood event. To get a deeper understanding of preferences, that evacuee were asked to fill questionnaire form. The questionnaire was distributed also via Twitter to their account. As a result, only 3 evacuees from 184 accounts sent the feedback. Based on this research we could conclude that VGI was not a proper media to get deeper feedback from the community.

As a discussion, Brabham (2009) mentioned that VGI was a potential method to had public participation in urban planning project, this argumentation might true with some limitations. Based on this research, people will give information on twitter related to the popular issue. They will voluntarily give information about flood and evacuation shelter depends on how large the flood event was. The flood event of 2013/2014 was greater than 2014/2015. Thus, the relevance twitter was also higher. Holderness and Turpin (2015) analysed that there was increased traffic of Twitter report related to flood during that period (Please refer to Figure 59). This proved that specific public issues would increase the participation of people through VGI.

However, when people were asked to give further information on the same issue and with the long list of the questionnaire, they refused. It was contradictive with Brabham (2009), that the process of people participation by forming the solutions and the community also possible to evaluate them. This might give argumentation that the evaluation from the community was always in term of voluntarily.

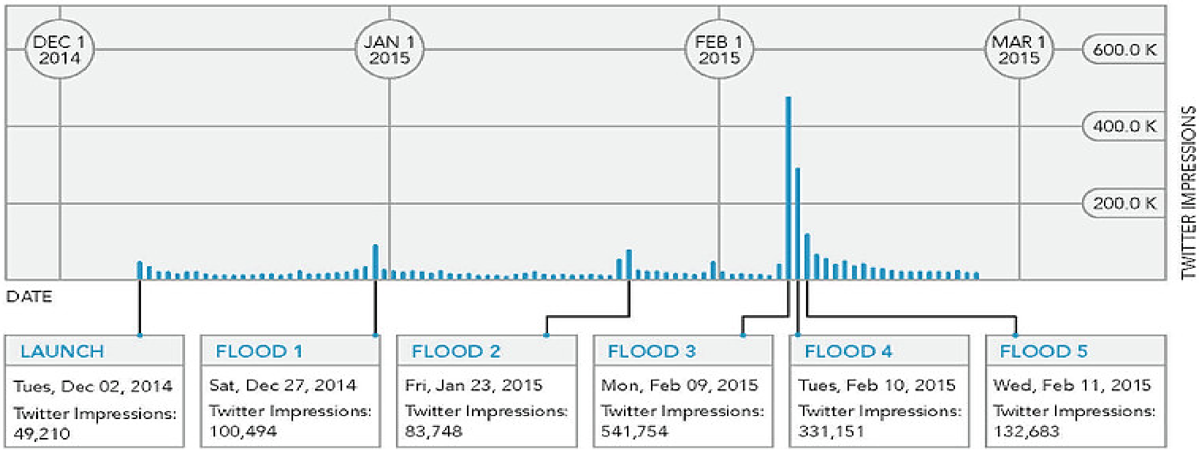


Figure 59 Twitter Impression during Flood Event 2014/2015 (Holderness and Turpin, 2015)

On the whole, the VGI in assessing site suitability of community flood evacuation shelters has given beneficial even limitations were also appear. The VGI could captured the community preferences of evacuation shelters in general through the location identification. What people thought during flood evacuation in previous flood event could be analysed using VGI. However, the technical drawbacks in using VGI could be improved by several approach. One of approach in improving the use of VGI that was the analysis could also be combined with other approaches. As mentioned by Goodchild and Li (2012), VGI have a part as an initial and hypothesis-generating step of the research. Since up to now, due to technological limitations (e.g. accuracy), VGI still weak in capturing depth preferences.

4.5 Limitations and Improvements for Future Assessments

According to this research, there are several recommendation as an improvement for further research. First, in this research, the process of content analysis of Twitter dataset was conducted manually. To increase the speed of data analysis, the process could be using automated text mining and machine learning classifications. However, the process should also be correlated with manual coding, since the content analysis of human language has many variations, e.g. characteristic of each language (English, Bahasa, etc.) and characteristic of the user (young, old, etc.).

Secondly, in this research, the content analysis only used to detect the spatial preferences of evacuation shelters. Means that the content analysis only focusing on identification of the evacuation shelter locations. Further research could also consider community preferences, such as perception, behaviour and sentiment analysis from twitter dataset.

As a general recommendation, another type of geolocated social media could also be practiced (e.g. Flickr and OpenStreetMap). Every type of platforms has their own characteristic. By determining each type of VGI can give better understanding on the usefulness of VGI to assess community evacuation shelter in specific and disaster management in urban planning in general.

5. CONCLUSION

Volunteered Geographic Information has been used in many research related to disaster management. The VGI was generally used in case of disaster emergency response on account of its real-time data providing (Erskine & Gregg, 2012; Goodchild & Glennon, 2010). However, the VGI had not been used much in urban planning field in relation with disaster emergency response. This research focussed on using VGI in evacuation shelter planning as one of a crucial part of emergency response.

In a case study of Jakarta, this research was captured community knowledge by applying VGI. The evacuation shelter preferred by the community in the last flood event was identified from geolocated Twitter data, as one of VGI. Those evacuation shelters were assessed their site suitability based on criteria of the local experts. Hence, evacuation shelter that integrating community and expert knowledge could increase the resilience of the community (UNHCR, 2007).

The first stage was generating data from Twitter. It was performed with data retrieval, data cleaning and content analysis (Vidal et al., 2015). To assure the quality of the data, content analysis was conducted. As a result, from 171.046 tweets with the keyword of the flood in December 2013/March 2014 and December 2014/March 2015, only 306 proper content of evacuation shelter was identified. Several issues were identified. One of the most important was the use of the keyword. Each language had their own characteristic. The use of synonym, slang word and connotation influenced the output of the analysis.

Before adopting the twitter dataset in further suitability analysis, we should determine the spatial pattern of it. Through identification of spatial pattern we could analyse a simple validation of that dataset. The result shows that the tweets clustered in the flood area. Though few location were far from flood area, we could not claim that those locations were inaccurate. Furthermore, accuracy assessment was also conducted to recognize the deviation between geolocation and the actual location mentioned within twitter text. In this case, the mean distance was 188 meters.

Moreover, as we need to assess the site suitability of the shelter, the proper spatial unit should be decided. Taking the mean distance as considerations, the proper spatial unit was hexagon with 200 meter of equal side length. Since hexagon has equal distance on each lines, this give advantage when conducting modelling distribution (Birch et al., 2007). Subsequently, 215 hexagon of evacuation shelter site were identified.

The prepared data from twitter was used to get deeper analysis on community preference of evacuation shelter. First, in compare to formal evacuation shelter site, 35,6% of community evacuation shelter based on twitter, were intersected with formal evacuation shelter. Since the spatial unit of community and formal was differ (hexagon and land use zone), we could only argue that 35,6% was the possibility of people using formal evacuation shelter.

Ideally, in getting deeper impression of community preference, people were asked to fill questionnaire or interview. Within this research, questionnaire distributed using twitter account of people indicated as evacuee (based on content analysis related to the user). Using twitter on get people feedback of specific case was not easy. From 184 accounts only 3 gave their feedback.

As an integrated approach to community and expert knowledge, evacuation shelter site of community preferences was assessed the suitability using expert criteria. Based on local expert choice, 11 criteria in 7 category of evacuation shelter site suitability were selected. The local expert also gave weight to each category and criteria. Those category listed from the highest were Accessibility (proximity to local road, proximity to main road, proximity to population, proximity to secondary road), Capacity (size of shelter site), Availability of facilities (electricity), Security and Protection (distance to potential/secondary hazards, distance from national vital object), Land use, building code and land right (land use and land right), and Topography, drainage and soil conditions (flood zone, slopes).

The result of composite index suitability analysis shows that the highest score was the medium classification with 127 sites out of 215. The sites dispersed throughout the city. Furthermore, only 29 sites were in high suitable class and 59 sites as the low suitable class. The final score of suitability influenced by the high number of high accessibility, as this category had the highest weight. So that, the high and medium suitable performed in the residential area and near to the local road. On the other hand, the topography category had the lowest number of suitability.

Based on community preferences on evacuation shelter site and those assessed by local expert criteria, we could summarize that accessibility was considered most by both. The shelters that near to their house was most preferred by the community. Local expert agreed by given the highest weight to accessibility category. People also seem not that worry if the locations were near the flood area. As we can find that the category of topography had a most low suitability score. It influenced by the lowest weight given by the local experts and the evacuation shelters that mostly inside the flood area.

At the end, this research was evaluating the usefulness of VGI based on each step of the analysis. There were benefits and drawbacks on using VGI in assessing site suitability of community evacuation shelter. Some of the benefits that the VGI could capture information of evacuation shelter related to near-time information during flood events. VGI could also capture a large area of study in a short time without fieldwork. Another benefit of using VGI was that this platform could give much information within the content analysis such as the user characteristic and time frame.

Aside from benefits, there were also drawbacks on using VGI in evacuation shelter analysis. One of the most mentioned by another researcher was related to the accuracy. In this research, accuracy problems influenced the result of the analysis. The spatial unit was one of them. Since the accuracy was more than 188 meters, the spatial unit could not be too detailed. Moreover, the general spatial unit also influenced the criteria to be used in suitability analysis. The criteria that needed detailed spatial unit, e.g. capacity of the building, could not be part of the assessment. Other drawbacks of VGI related on the limitation on getting feedback from the community. The respondent, which were asked to fill the questionnaire via their twitter account, only about 2% gave their feedback.

In overall, the VGI has given a useful approach in capturing community preferences of evacuation shelter and integrated it with the expert criteria. The VGI data could be adopted as preliminary data of the general and broad area. Further, collaborating VGI and other approach could give better understanding of community preferences in a particular spatial planning problems.

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APPENDICES

APPENDIX 1 QUESTIONNAIRE SAMPLE

Preferences on Evacuation Shelter Questionnaire (Community)

1. Contact
   Name :
   Twitter :
   Email Address :
   Home Address :

2. In previous flood event 2014 and 2015, where was evacuation shelter that you use? (address)

3. How many times you use this location as evacuation shelter?

4. Why you choose this location as evacuation shelter?

5. How do you get to that evacuation shelter (by walk/bus/car/etc.)?

6. What kind of building that you use as evacuation shelter? (e.g. house, sport hall, shop, tent)

7. Who provide this location?
   a. Government
   b. Private
   c. Family /Friend
   d. Others:

8. How long you stay in this location as evacuation shelter?

9. In non-flood condition, do you often visit this place?
   a.Yes
   b. No

10. If yes, why?

11. How is the facilities provided in your previous evacuation shelter?

	Provided	Not Provided
Water		
Drainage		
Waste		
Electricity		
Others…		

12. How is the condition of facilities in your previous evacuation shelter?

	Very good	Good	Fair	Poor	Very Poor
Water					
Drainage					
Waste					

Electricity					
Others…					

13. How far is the evacuation shelter to your house?

Very near	Near	Far	Very far

14. How many meters?

15. How far is the evacuation shelter to the main road?

Very near	Near	Far	Very far

16. How many meters?

17. How far is the evacuation shelter to the flood area?

Very near	Near	Far	Very far

18. How many meters?

19. Is there any other evacuation shelter you usually use?
    a. Yes
    b. No

20. If yes, what is the address?

21. Why you choose those location?

22. Do you notice the evacuation shelter provide by the government near your home?
    a. Yes
    b. No

23. If yes, where is it?(address)

24. How far is that location from your home?

25. Do you ever use that evacuation shelter provided by the government in previous flood event? Why?

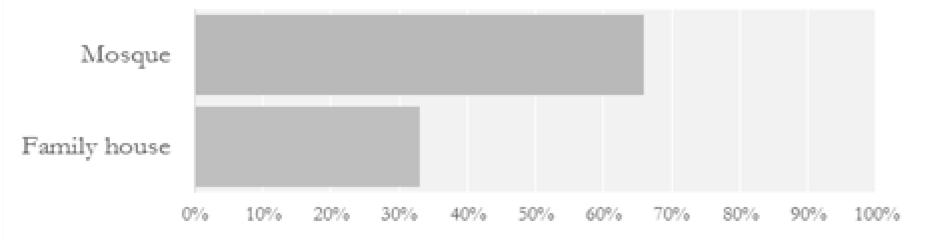
26. If there is no evacuation shelter, where do you prefer to evacuate yourself?

APPENDIX 2 QUESTIONNAIRE (RESULT SUMMARY)

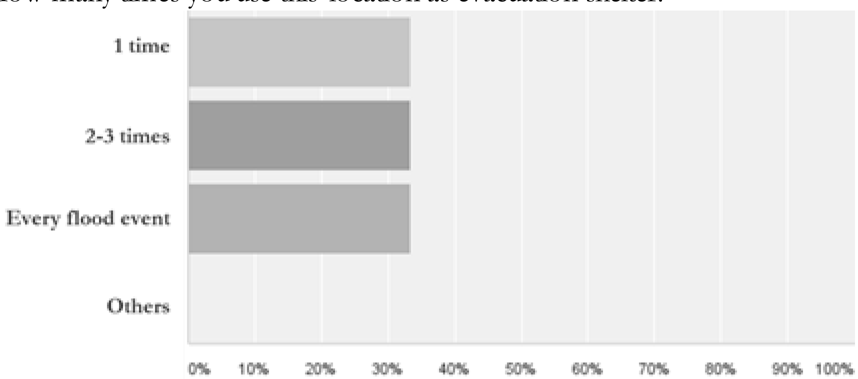
Preferences on Evacuation Shelter Questionnaire (Community)

1. Total respondents: 184 twitter account
   Total responses: 3 twitter account

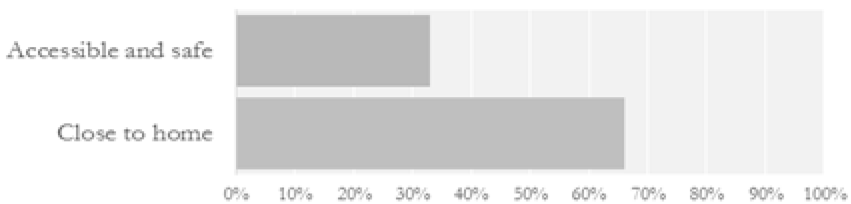
2. In previous flood event 2014 and 2015, where was evacuation shelter that you use? (address)



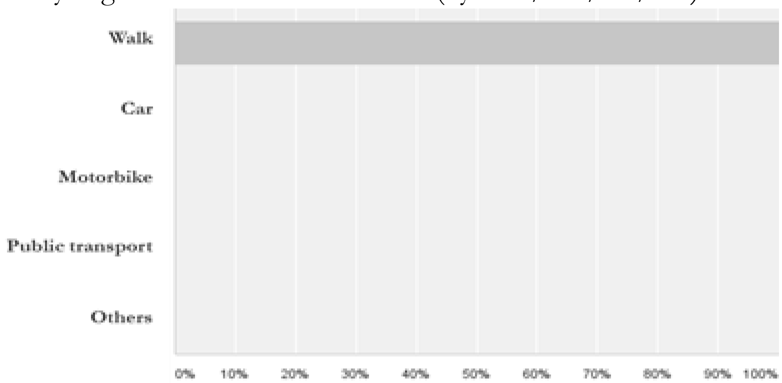
3. How many times you use this location as evacuation shelter?



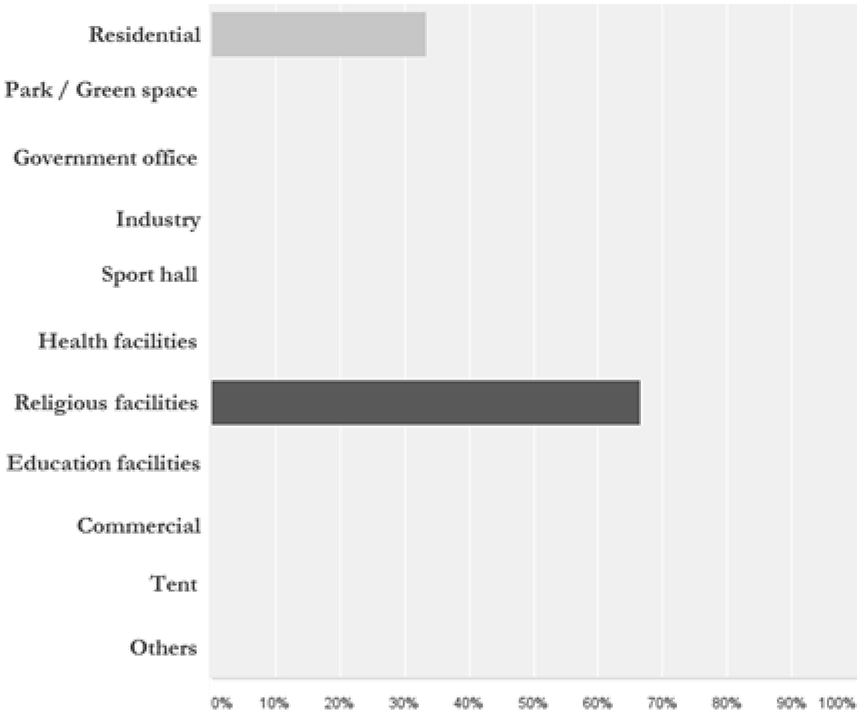
4. Why you choose this location as evacuation shelter?



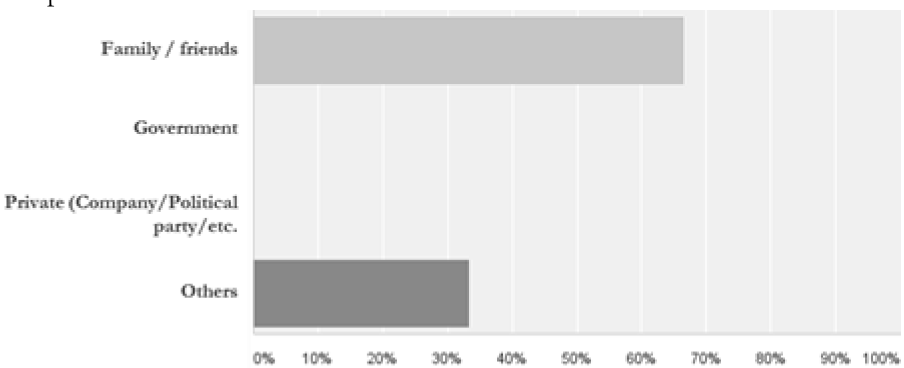
5. How do you get to that evacuation shelter (by walk/bus/car/etc.)?



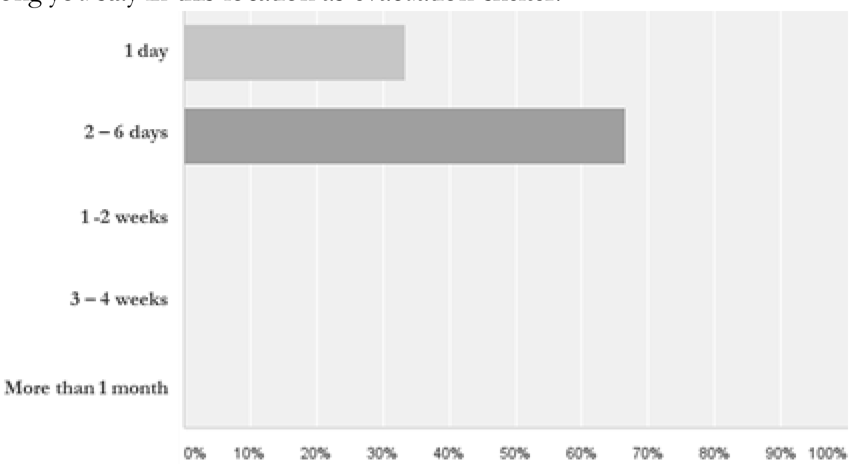
6. What kind of building that you use as evacuation shelter? (e.g. house, sport hall, shop, tent)



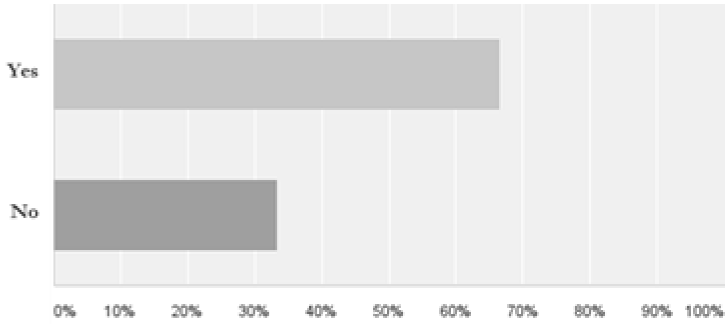
7. Who provide this location?



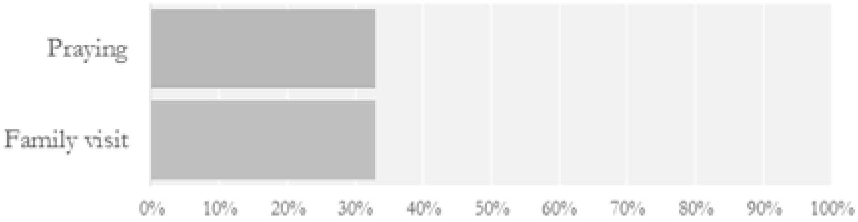
8. How long you stay in this location as evacuation shelter?



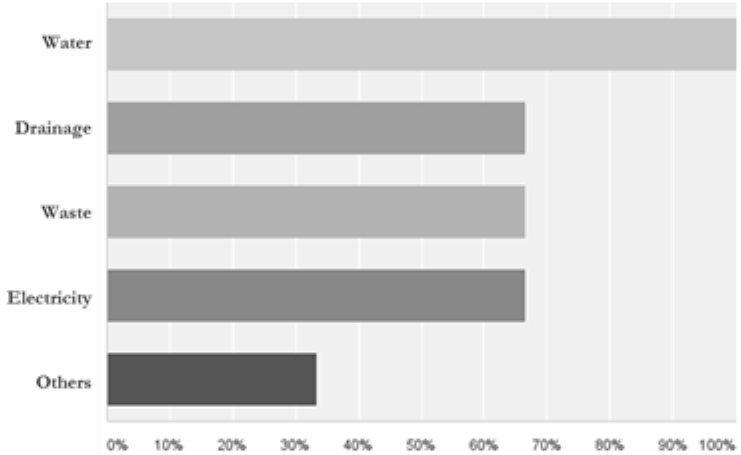
9. In non-flood condition, do you often visit this place?



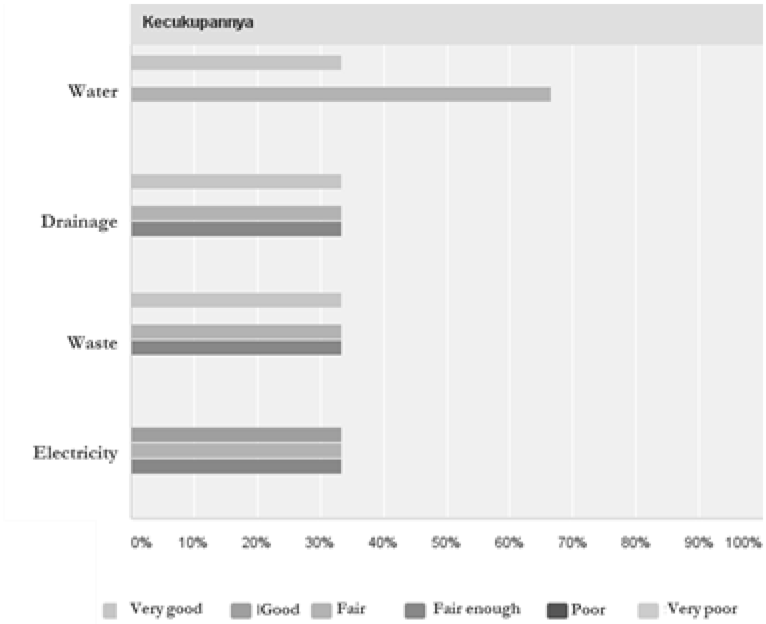
10. If yes, why?



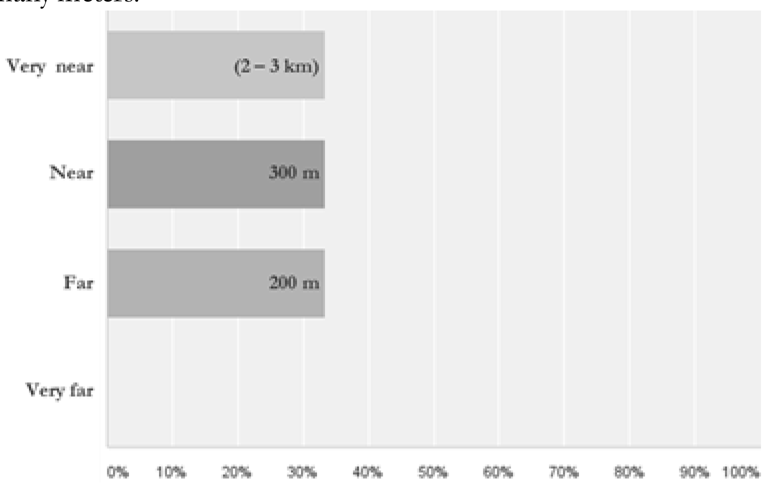
11. How is the facilities provided in your previous evacuation shelter?



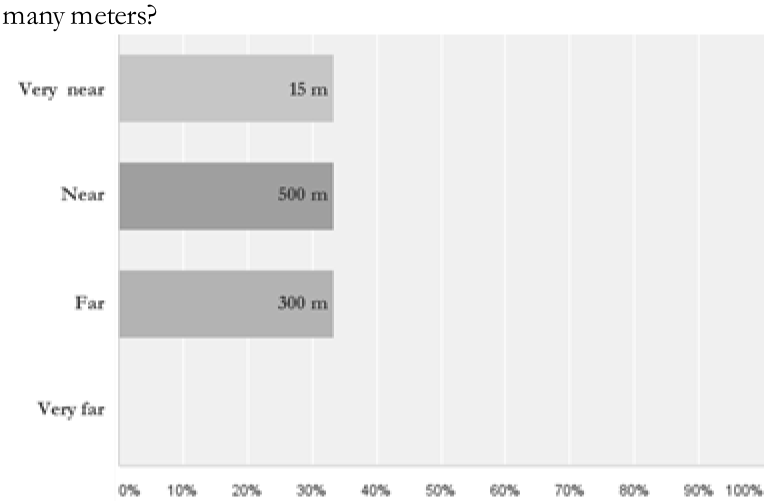
12. How is the condition of facilities in your previous evacuation shelter?



13. How far is the evacuation shelter to your house?
14. How many meters?

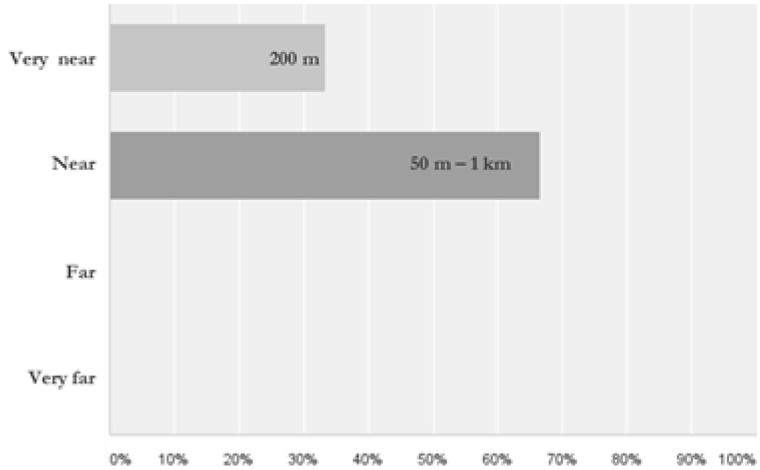


15. How far is the evacuation shelter to the main road?
16. How many meters?

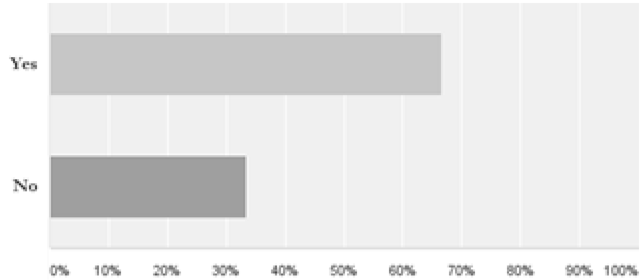


17. How far is the evacuation shelter to the flood area?

18. How many meters?

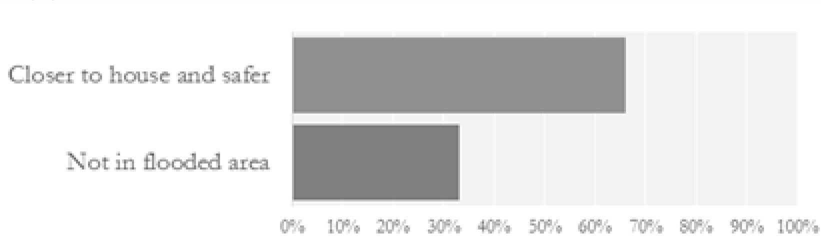


19. Is there any other evacuation shelter you usually use?

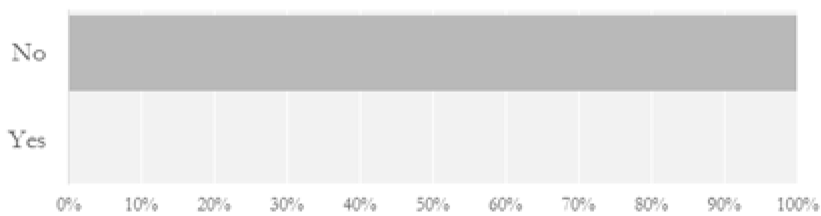


20. If yes, what is the address?

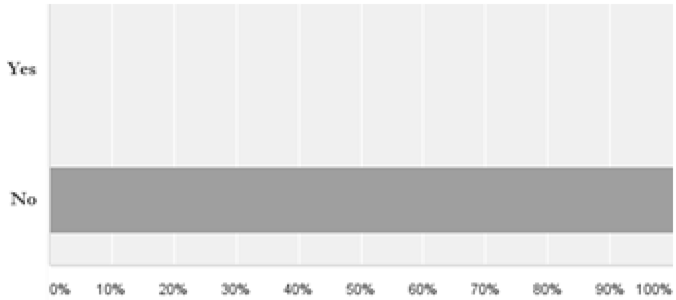
21. Why you choose those location?



22. Do you notice the evacuation shelter provide by the government near your home?



23. If yes, where is it?(address)
24. Do you ever use that evacuation shelter provided by the government in previous flood event?



25. Why?
    No information, government usually provide the shelter after the flood

26. If there is no evacuation shelter, where do you prefer to evacuate yourself?
    Hotel, family house, neighbour with two floor house

APPENDIX 3 EXPERT CHOICE ON EVACUATION SHELTER SUITABILITY CRITERIA

Category	Sites Criteria	Expert					Total
		1	2	3	4	5	
A. Topography, drainage and soil conditions	Slopes	<5%	<5%	<5%	<5%	<10%	5
	Soil conditions	-	V	-	-	V	2
	Flood Zone	Future flood	Past flood time series (2002, 2007, etc)	Future flood	Future flood simulation	Not located in a 100 year flood zone	5
	Other:........ Land subsidence	-	Not in risk area	-	-		1
B. Accessibility	Proximity to health care services	-	-	-	-	V	1
	Proximity to main road	Nearest to	Nearest to	-	Nearest to	100 m	4
	Proximity to secondary road	Nearest to	Nearest to	-	Nearest to	100 m	4
	Proximity to population	Located in residential area	Located in residential area	Located in residential area	-		3
	Distance between each shelter	-	500 m	-	-	200 m	2
	Other:........ Proximity to local road	Accessed by 3 m local road	Accessed by 3 m local road	Accessed by 3 m local road	-		3
C. Availability of Facilities	Water	-	-	-	V	Distance <500m	2
	Waste	-	-	-	-	V	1
	Other:........ Electricity	-	Electricity (near to generator / power station)	-	Electricity (near to generator / power station)	Electricity (near to generator / power station)	3
D. Capacity	Size of shelter sites	3 m²	3 m²	3 m²	5 m² include facilities	3 m²	5
	Other:........	-	-	-	-	-	-
E. Land use, building code and land right	Land use and land rights	Owned by the government	Owned by the government (park, sporthall)	Owned by the government	follow the plan	Owned by the government	5
	Other:........	-	-	-	-		

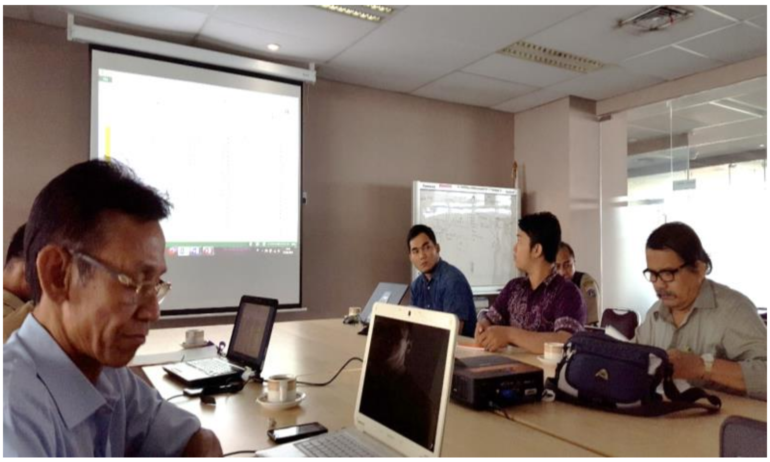
Category	Sites Criteria	Expert					Total
		1	2	3	4	5	
F. Security and protection	Distance from international borders	-	-	-	-	-	
	Away from potential and secondary hazards	far from hazardous facilities	-	-	far from hazardous facilities	100 m	3
	Distance from military installations	-	-	-	far from military installations	-	1
	Other:........ Distance from electricity installations	Far from high voltage electricity installations	Far from high voltage electricity installations	-	-	-	2
	Other:........ Distance from national vital object (symbol Negara, hankam, energy)	-	Distance from national vital object (port, airport, istana)	-	Distance from national vital object (port, airport, istana)	Distance from national vital object (port, airport, istana)	3
G. Climatic conditions, local health and other risks	Local health condition	-	-	-	-	V	1
	Climatic conditions	-	-	-	-	V	1
	Other:........	-	-	-	-		-
H. Vegetation	Ground cover	-	-	-	-	V	1
	Other:........	-	-	-	-		-

Expert 1 : Jakarta Disaster Management Agency (BPBD)
Expert 2 : Jakarta City Planning Department (DPK)
Expert 3 : NGO: Jakarta Rescue
Expert 4 : Indonesia Association of Urban and Regional Planners of Jakarta (IAP Jakarta)
Expert 5 : Disaster Risk Management Specialist

APPENDIX 4 WEIGHTED BY THE LOCAL EXPERT

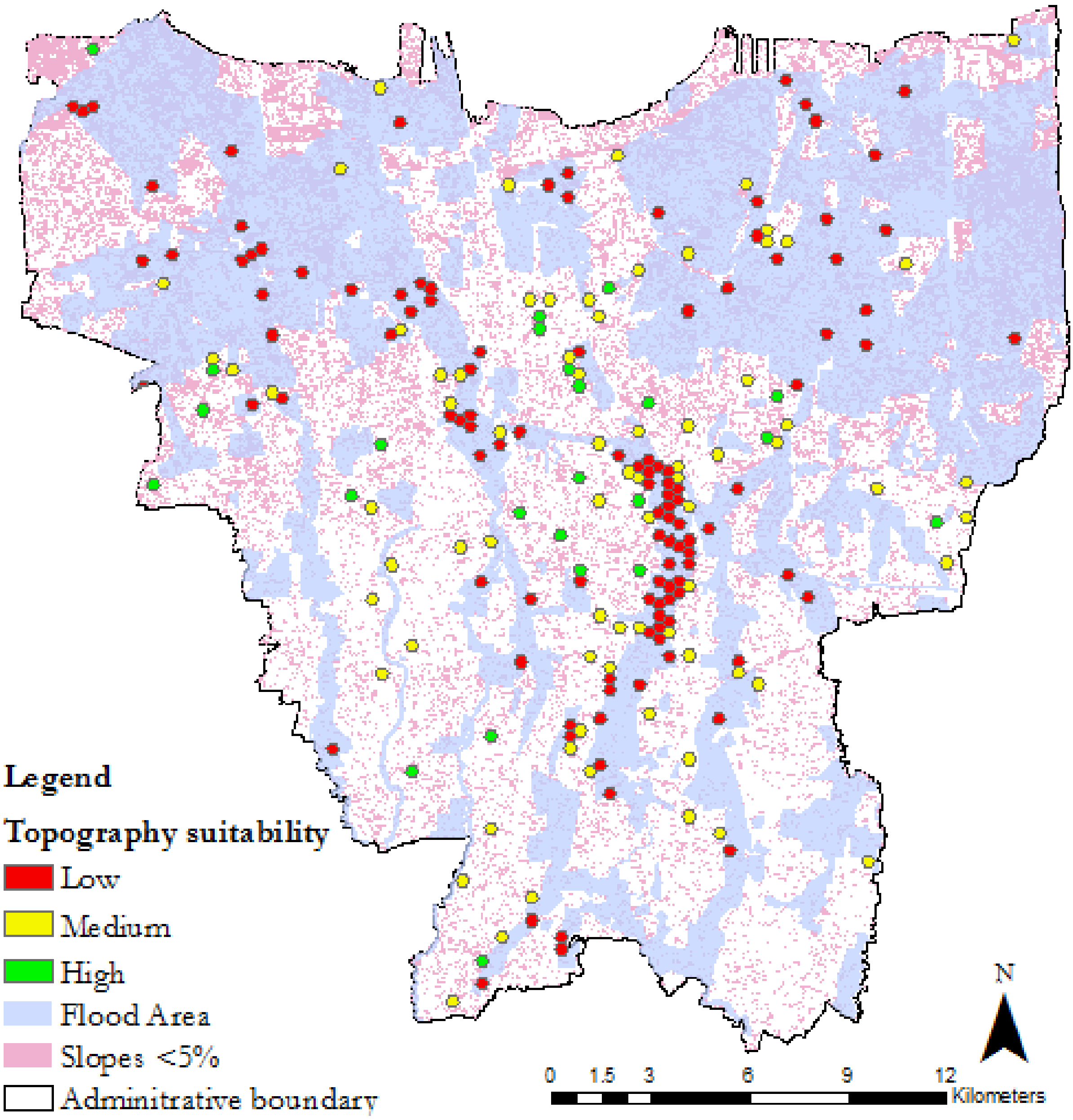
Category		Sites Criteria	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average
A.	Topography, drainage and soil conditions		**0.051**	**0.063**	**0.035**	**0.090**	**0.096**	**0.06**
		Slopes	0.500	0.900	0.100	0.250	0.500	**0.45**
		Flood Zone	0.500	0.100	0.900	0.750	0.500	**0.55**
B.	Accessibility		**0.216**	**0.366**	**0.208**	**0.349**	**0.041**	**0.24**
		Proximity to main road	0.144	0.260	0.061	0.391	0.208	**0.27**
		Proximity to secondary road	0.144	0.087	0.147	0.276	0.201	**0.21**
		Proximity to local road	0.392	0.300	0.381	0.195	0.365	**0.29**
		Proximity to population	0.320	0.622	0.411	0.138	0.225	**0.23**
C.	Availability of Facilities		**0.036**	**0.161**	**0.370**	**0.245**	**0.168**	**0.20**
		Electricity	1	1	1	1	1	**1.00**
D.	Capacity		**0.556**	**0.098**	**0.213**	**0.167**	**0.143**	**0.24**
		Size of shelter sites	1	1	1	1	1	**1.00**
E.	Land use, building code and land right		**0.021**	**0.109**	**0.02**	**0.072**	**0.205**	**0.09**
		Land use and land rights	1	1	1	1	1	**1.00**
F.	Security and protection		**0.120**	**0.203**	**0.151**	**0.077**	**0.348**	**0.18**
		Away from potential and secondary hazards	0.500	0.875	0.900	0.667	0.167	**0.67**
		Distance from national vital object	0.500	0.125	0.100	0.333	0.833	**0.33**

Expert 1 : Jakarta Disaster Management Agency (BPBD)
Expert 2 : Jakarta City Planning Department (DPK)
Expert 3 : NGO: Jakarta Rescue
Expert 4 : Indonesia Association of Urban and Regional Planners of Jakarta (IAP Jakarta)
Expert 5 : Disaster Risk Management Specialist

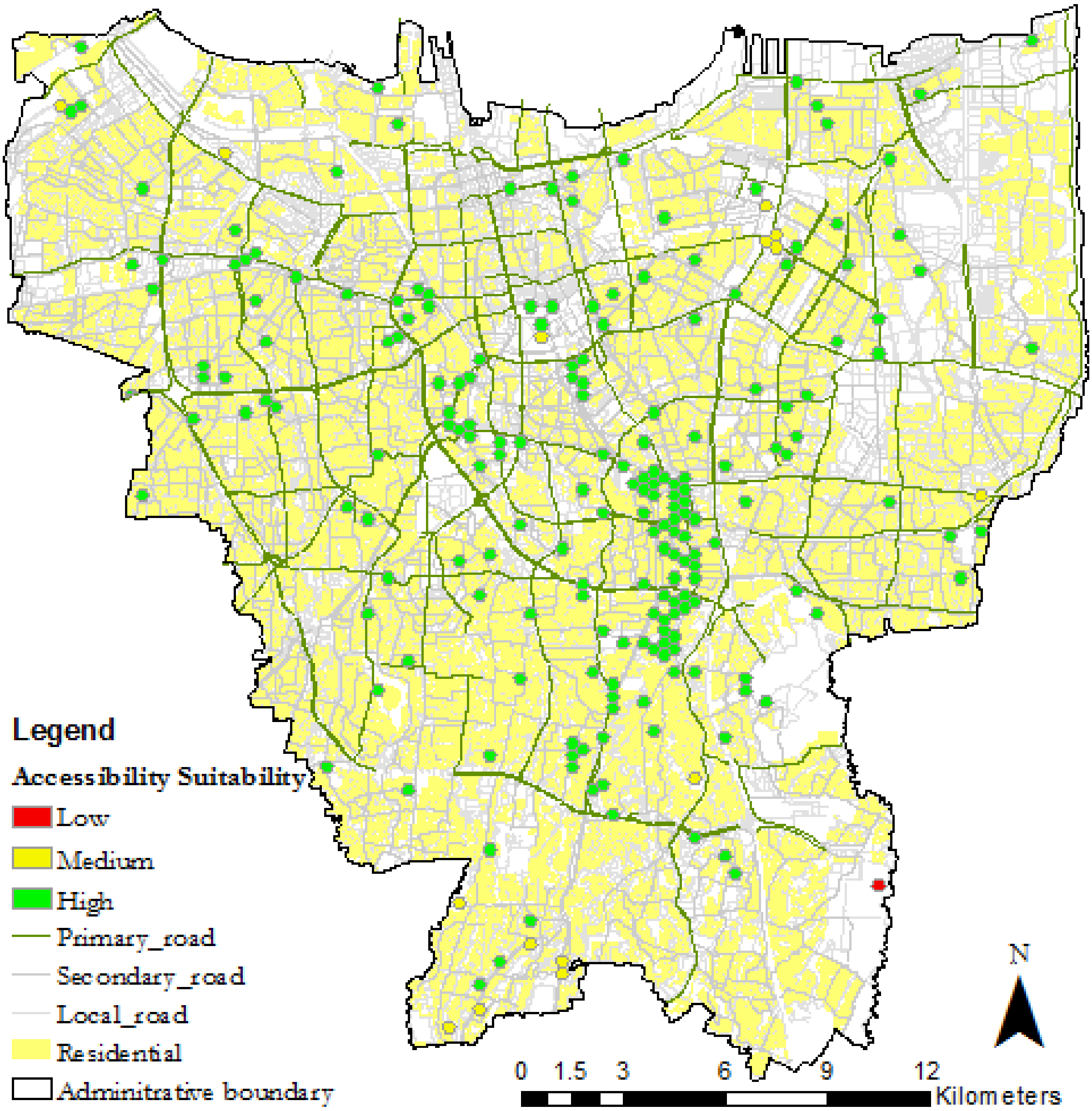


APPENDIX 5 SUITABILITY MAPS

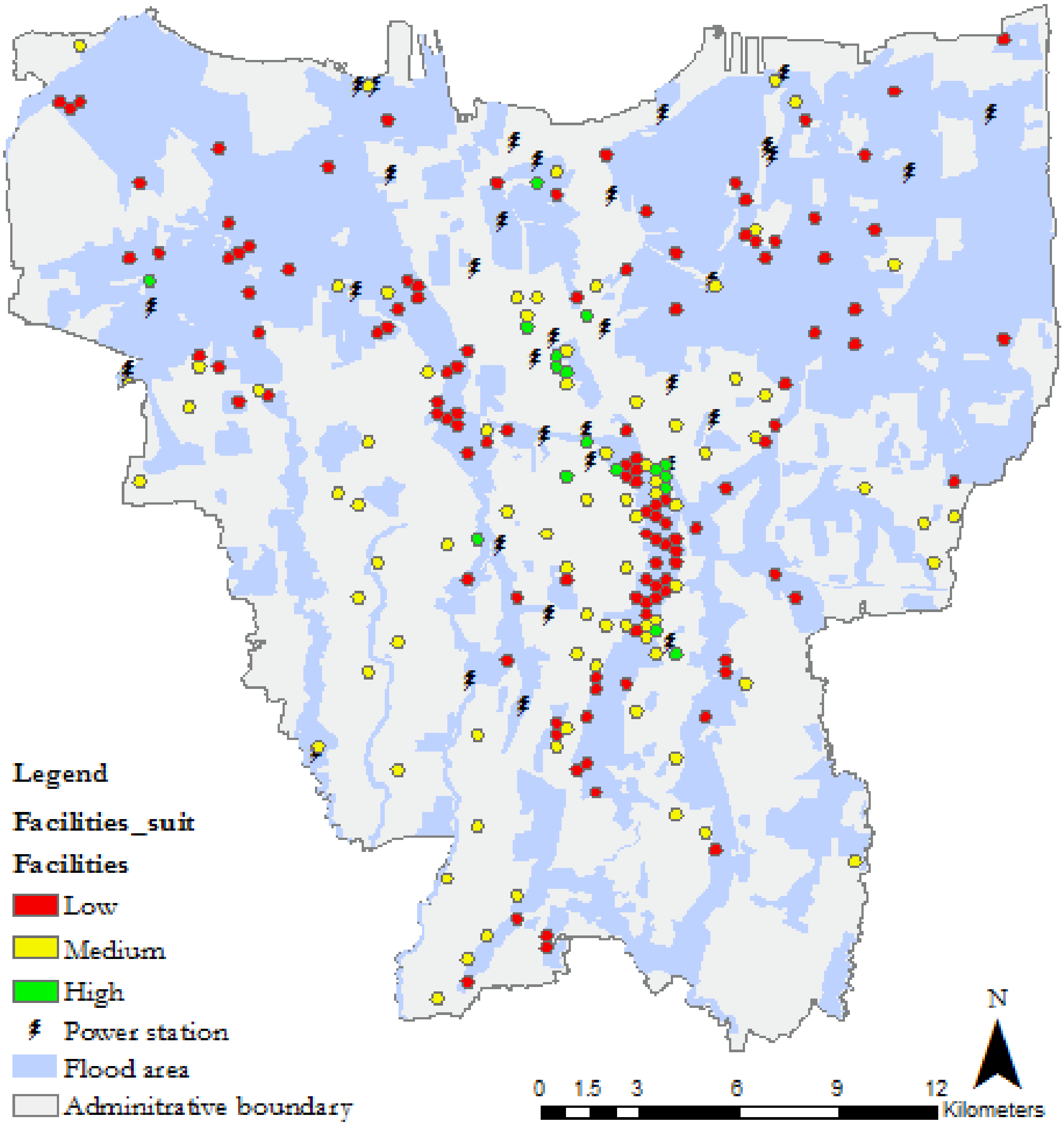
Suitability map of topography, drainage and soil condition



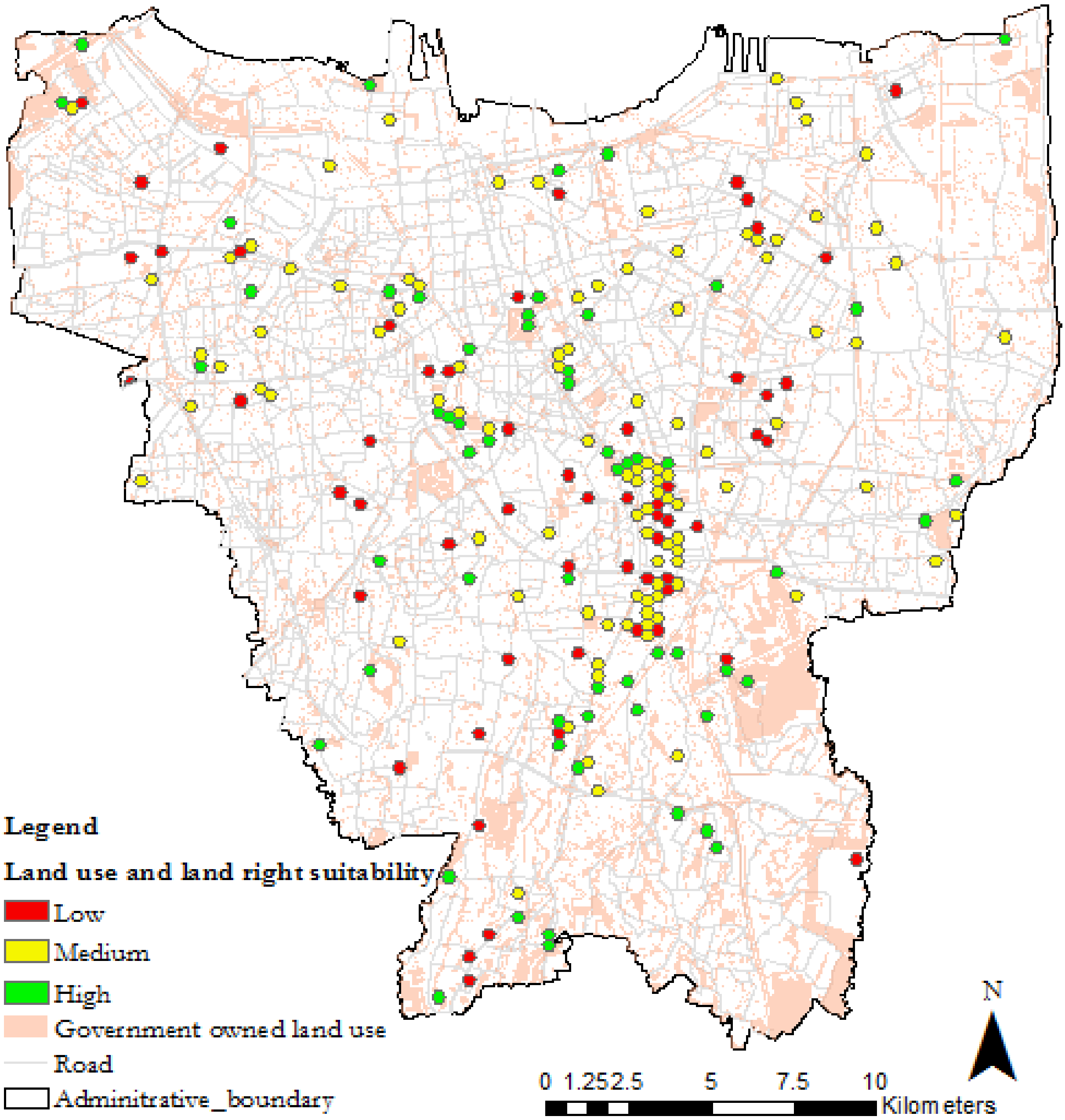
Suitability map of accessibility



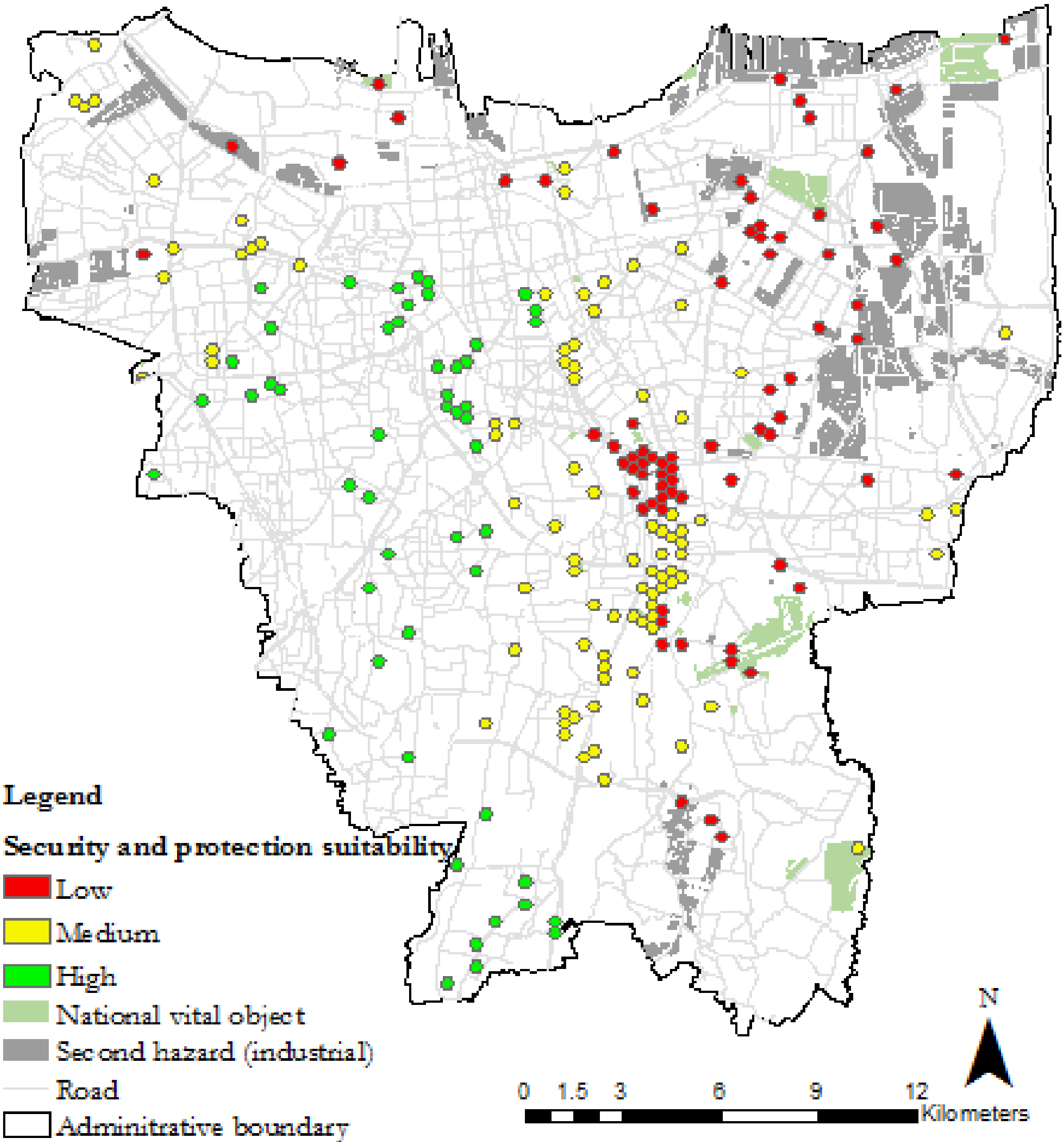
Suitability map of facility



Suitability map of land use, building code and land right



Suitability map of security and protection



APPENDIX 6 ACCURACY ASSESSMENT TABLE

Distance between geolocation and actual location (mentioned in twitter text). Coordinate system WGS 1984 UTM Zone 48S.

X2	Y2	X1	Y1	Shape_Length	Distance (meter)
106.8392	-6.1889	106.8392	-6.1889	0	0
106.81162	-6.35589	106.81162	-6.35589	0	0
106.85778	-6.21084	106.85778	-6.21084	0	0
106.73736	-6.1871	106.73736	-6.1871	0	0
106.86201	-6.2139	106.86201	-6.2139	0	0
106.86265	-6.2576	106.86265	-6.2576	0	0
106.8622706	-6.21407917	106.8622706	-6.21407917	0	0
106.88371	-6.22067	106.88371	-6.22067	0	0
106.86203	-6.21371	106.86203	-6.21371	0	0
106.86231	-6.21454	106.86231	-6.21454	0	0
106.86185	-6.21345	106.86185	-6.21345	0	0
106.83868	-6.19108	106.83868	-6.19108	0	0
106.89075	-6.14933	106.89075	-6.14933	0	0
106.79895	-6.16683	106.79895	-6.16683	0	0
106.82993	-6.16915	106.82993	-6.16915	0	0
106.77223	-6.28985	106.77223	-6.28985	0	0
106.89737	-6.24357	106.89737	-6.24357	0	0
106.9100404	-6.15824084	106.9100404	-6.15824084	0	0
106.78954	-6.17587	106.78954	-6.17587	0	0
106.86556	-6.24421	106.86556	-6.24421	0	0
106.78848	-6.17668	106.78848	-6.17668	0	0
106.86182	-6.24429	106.86182	-6.24429	0	0
106.84491	-6.28334	106.84491	-6.28334	0	0
106.95851	-6.09709	106.95851	-6.09709	0	0
106.82706	-6.17699	106.82706	-6.17699	0	0
106.89718	-6.151864	106.89718	-6.151864	0	0
106.83963	-6.24385	106.83963	-6.24385	0	0
106.86282	-6.25761	106.86282	-6.25761	0	0
106.79048	-6.16739	106.79048	-6.16739	0	0
106.7432852	-6.129297896	106.7433	-6.12925	5.01255E-05	5.543997565
106.8607834	-6.25107789	106.8606975	-6.25111049	9.19229E-05	10.17277736
106.8936925	-6.15705435	106.893592	-6.157026	0.00010441	11.55715201
106.8938658	-6.157200701	106.89393	-6.1571	0.000119413	13.21071081
106.7384224	-6.184971542	106.73841	-6.18484	0.000132123	14.6121101
106.8082234	-6.20165951	106.80808	-6.20166	0.000143428	15.87501104
106.8682312	-6.238684971	106.86839	-6.23881	0.000202127	22.36523846
106.7375393	-6.184998022	106.73758	-6.18477	0.000231618	25.61611458
106.8802922	-6.163389373	106.88052	-6.16343	0.000231417	25.61613122
106.8184047	-6.203659647	106.81819	-6.20378	0.000246158	27.24056196
106.8907034	-6.151501693	106.89058	-6.15173	0.000259512	28.70834417

X2	Y2	X1	Y1	Shape_Length	Distance (meter)
106.8596626	-6.225212665	106.85952	-6.22545	0.000276878	30.62889795
106.8628635	-6.257536771	106.86267	-6.25733	0.000283217	31.33381877
106.8452739	-6.294282622	106.84507	-6.29408	0.000287483	31.80517281
106.8452739	-6.294282622	106.84507	-6.29408	0.000287483	31.80517281
106.8452361	-6.294398056	106.84493	-6.29438	0.000306625	33.93280376
106.862116	-6.214237741	106.86231	-6.21454	0.000359169	39.73314272
106.8628687	-6.25753667	106.86271	-6.25713	0.00043653	48.28505728
106.863057	-6.257745658	106.86294	-6.25729	0.000470438	52.0332678
106.863057	-6.257745658	106.86266	-6.25747	0.000483315	53.47914281
106.8620793	-6.21414255	106.8625875	-6.21385369	0.000584517	64.68466285
106.8686234	-6.234705405	106.868	-6.23494	0.00066607	73.71402522
106.8621079	-6.214244382	106.86249	-6.21481	0.000682572	75.51086576
106.8620793	-6.21414255	106.86189	-6.21347	0.000698696	77.28079261
106.906445	-6.177041848	106.90652	-6.1763	0.000745632	82.470469
106.8647647	-6.213696325	106.86525	-6.21302	0.000832409	92.08891034
106.8288863	-6.174084191	106.82893	-6.17317	0.000915235	101.224195
106.7905024	-6.117538997	106.79067	-6.11864	0.001113683	123.1718818
106.783111	-6.222738401	106.78278	-6.22384	0.001150244	127.2205096
106.8625303	-6.267736319	106.8631292	-6.26671988	0.001179733	130.5017968
106.8377352	-6.289632488	106.83731	-6.28839	0.001313214	145.2505071
106.8319827	-6.138598061	106.83225	-6.13709	0.001531571	169.3948583
106.863057	-6.257745658	106.8614834	-6.25826662	0.00165759	183.440908
106.8686234	-6.234705405	106.86813	-6.23309	0.001689073	186.8254861
106.8686234	-6.234705405	106.86813	-6.23309	0.001689073	186.8254861
106.8686234	-6.234705405	106.86813	-6.23309	0.001689073	186.8254861
106.8620793	-6.21414255	106.86088	-6.21293	0.001705494	188.6992506
106.8612052	-6.217811088	106.85925	-6.21855	0.002090177	231.3250838
106.8620793	-6.21414255	106.85989	-6.21464	0.00224515	248.4919536
106.863057	-6.257745658	106.86098	-6.25894	0.002395906	265.1218588
106.8686234	-6.234705405	106.86816	-6.2371	0.002439019	269.7663891
106.8043473	-6.197956038	106.80385	-6.19513	0.002869452	317.3616866
106.7247494	-6.161944223	106.72446	-6.16484	0.002910207	321.8503098
106.837673	-6.219465916	106.83976	-6.21743	0.002915579	322.5840337
106.837673	-6.219465916	106.83976	-6.21743	0.002915579	322.5840337
106.8626872	-6.257716698	106.85946	-6.25777	0.00322765	357.2182221
106.8618544	-6.213856194	106.8645	-6.21572	0.003236226	358.1086405
106.8627561	-6.257832846	106.8594	-6.25795	0.003358125	371.6581316
106.8391995	-6.190175386	106.8366813	-6.18777986	0.003475601	384.5601747
106.863057	-6.257745658	106.85937	-6.25798	0.003694436	408.8783641
106.8106792	-6.205247307	106.81227	-6.20906	0.00413124	456.9583496
106.8034387	-6.192380972	106.80193	-6.18805	0.004586232	507.2688311
106.8617811	-6.245035063	106.86359	-6.24955	0.004863834	537.9972496
106.8686234	-6.234705405	106.86648	-6.22998	0.005188793	573.9582576
106.84491	-6.28334	106.83958	-6.28698	0.00645434	714.147326
106.863057	-6.257745658	106.86642	-6.24869	0.009659955	1068.492133
106.8305419	-6.125341978	106.78365	-6.11172	0.048830422	5405.142024
				Average	**188.2809043**

APPENDIX 7 LAND USE MAP