THE USE OF HIGH RESOLUTION IMAGES TO EVALUATE THE EVENT OF FLOODS AND TO ANALYSE THE RISK REDUCTION CASE STUDY: KAMPUNG PULO, JAKARTA

M. Rokhis Khomarudin[1], Suwarsono[1], Dini Oktavia Ambarwati[1], and Gunawan Prabowo[2]
[1] Remote Sensing Application Center, LAPAN
[2]Aeronautics Technology Center, LAPAN
*e-mail: Rokhis.Khomarudin@lapan.go.id

Received: 1 July 2014; Revised: 6 August 2014; Approved: 14 October 2014

Abstract. The flood hit Kampung Pulo region in almost every year. This disaster has caused the evacuation of some residents in weeks. Given the frequency of occurrence is quite high in the region it is necessary to do a study to support disaster risk reduction. This study aimed to evaluate the incidence of flooding that occurred in Kampung Pulo in terms of topography, river conditions, characteristics of the building, and socioeconomic conditions. Methods of study include geomorphology analysis, identification of areas of stagnant, the estimated number of people exposed, the estimation of socio-economic conditions of the population, as well as determining the location of an evacuation. The data used is high-resolution remote sensing imagery is QuickBird and SPOT-6. It also used the results of aerial photography using Unmanned Aerial Vehicle (UAV). Aerial photography was conducted on January 18, 2013, which is when the serious flooding that inundated almost the entire region of Kampung Pulo. Information risk level of buildings and population resulting from this study were obtained by using GIS. The results obtained from this study can be used to develop recommendations and strategies for flood mitigation in Kampung Pulo, Jakarta. One of them is the determination of the location for vertical evacuation plan in the affected areas.

Key Words: *Flood risk, Kampung Pulo, High-resolution remote sensing, UAV1*

1 INTRODUCTION

Flooding in the area of Kampung Pulo of Jakarta in 2013 occurred back in 2014 that led to thousands of residents in the area to evacuate. Naturally, Pulo village is a flood plain area of the Ciliwung river. In addition, this area is a residential area with a high population density. Due to a flood plain, in the rainy season, rain water easily reach the volume that exceeds the capacity of the river channel, causing flooding that inundated Kampung Pulo area. One effort that is often touted to reduce the risk of flooding in this region is to vacate the residents along the river. However, paying attention to the current conditions, ie with the number of people living in the region, could relocate so many people who have been living for generations for decades.

To reduce a risk of disaster, efforts should be made to reduce the level of danger, reduce vulnerability, and increase the capacity of communities to cope with flooding in. To reduce the danger level is rather difficult to be pursued, as this is something that given the existence. In an effort to reduce vulnerability, one effort is to reduce the exposure in the danger area, which means relocating people in the area. This effort would be difficult to do in addition to requiring a very large cost also considering socioeconomic factors, particularly their resistance citizen who resisted relocation. One effort that may do is increase people's capacity to cope with

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flooding. Society is conditioned to live in harmony with flooding, so they are always ready and alert to the threat of flooding.

When viewed from the problem of flooding in Jakarta, there are three issues that can cause flooding. The first is because of the high river flow from upstream flows to the downstream area in Jakarta. The second is local rainfall that hit Jakarta in a few days on the one hand and the condition of the surface of the land that was no longer able to absorb rainwater. The third is the tidal flood of sea usually hits in the northern part of Jakarta. Pulo village flooding can be caused by problems in the first, second, third, or a mix between the three. If at one time it rains with high intensity long duration Dengah throughout Greater Jakarta and is accompanied by the ocean tides in the Bay of Jakarta, then the condition will cause flooding, especially in the area of Kampung Pulo.

Natural characteristics that control the incidence of flooding in the region will affect how for early warning of the flood events of the region. For the case of Kampung Pulo, the first way to do is if rainfall occurs in Bogor not stopped for two days in a row, then the flood warnings to the public must be done so that people can get ready. Second, in case of local rainfall with high intensity for 2 consecutive days, then the flood warnings should also be done so that people in the region get ready.

One of the research on the condition of vulnerability of communities to flooding in Kampung Melayu has been done by Marschiavelli (2008) which says that the poor are more vulnerable to flooding due to their inability to repair damage caused by flooding in the region. The study also warned that the government should be more concerned about the socioeconomic conditions in the reduction of the risk of flooding. Approach to increase capacity to cope with floods in the region recommended in such research. This approach needs to be implemented with increased community capacity. Juarni, et. al. (2013) which suggests to elevate homes in flood area. Other efforts in reducing the risk of flooding in Jakarta is the improvement of early warning systems (Rahayu and Nasu, 2009), flood modeling to determine flood-prone areas (Doan, *et al.*, 2012), and the reduction of poverty (Texier, 2008). One study of comprehensive flood risk reduction with use of flood hazard maps and socioeconomic been done by Iglesias (2012) and also by Texier (2008).

In the context of the use of remote sensing technology to support the flood disaster management has been done, which includes the detection, extraction and modeling mapping inundated areas flooded areas. Based optical data, have made use of the image for the extraction of the floodwaters (Yang *et al.*, 2011), for mapping the distribution of flood (Zhou *et al.*, 2002; Wang *et al.*, 2002; Wang *et al.,* 2004; Volpi *et al* ., 2013). Other uses such as for the modeling of flooded areas (Townsend & Walsh, 1998; Du *et al.*, 2012; Gheith & Sultan, 2002). In addition, the SAR data effectively and widely used for mapping flood-affected areas (Gan *et al.,* 2012; Arnesen *et al.*, 2013). From the aspect of geomorphology, Asriningrum (2002) have tried using Landsat data to test its ability to identify landforms, including flood plain fluvial landforms.

This research was conducted with the aim to evaluate the incidence of flooding and analysis of risk reduction by using a base of high resolution remote sensing data. The research location chosen is Kampung Pulo, Jakarta by taking the circumstances of time in 2013. It is expected that this research could make a recommendation and flood mitigation strategy in Kampung Pulo, Jakarta.

2 METHODS

2.1 Data

This study uses a UAV image data in the acquisition on January 18, 2013, QuickBird imagery data in 2010, and data SPOT-6 Tristereo 2013. The image data QuickBird and SPOT-6 has been corrected geometry. UAV image data corrected geometry using QuickBird data reference.

The study took place flood-prone area in Kampung Pulo. The use of the name of Kampung Pulo here represents a flood-prone area in the area of Ciliwung River meanders. Administratively, location research went into several villages, namely: Bidara Cina, Bukit Duri, Bali Mester, Kampung Melayu and Manggarai. Figure 2-1 shows the location of the research.

2.2 Method

The method of analysis performed in this study include geomorphology analysis, identification of areas of stagnant, the estimated number of people exposed, the estimation of socio-economic conditions of the population, as well as determining the location of an evacuation. Figure 2-2 shows a flowchart of processing and data analysis.

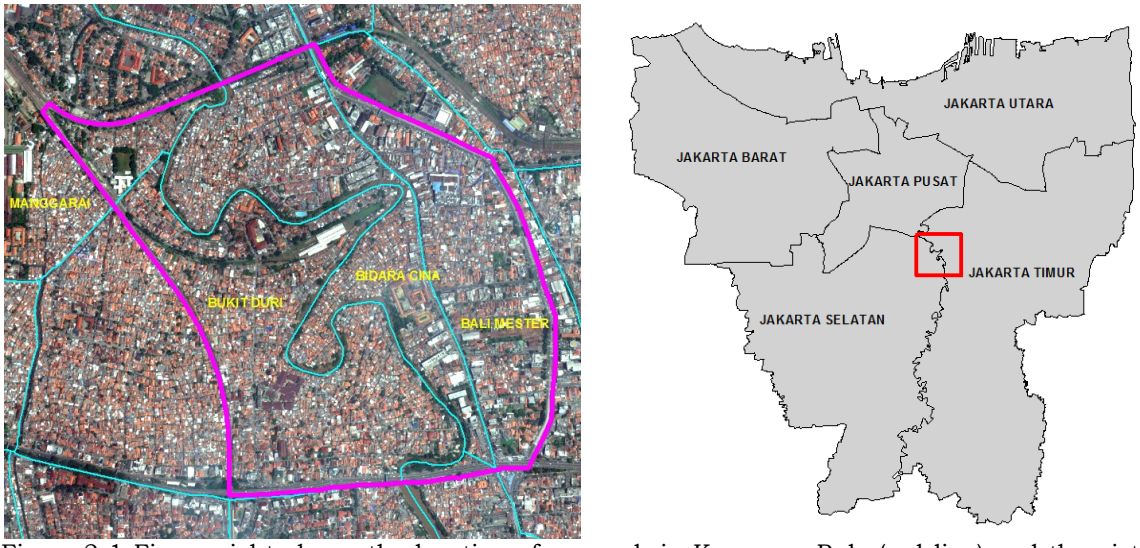

Figure 2-1: Figure right shows the location of research in Kampung Pulo (red line) and the picture on the left shows the appearance of the image of QuickBird in 2010 (purple line is the boundary location of research, light blue line is the administrative boundary)

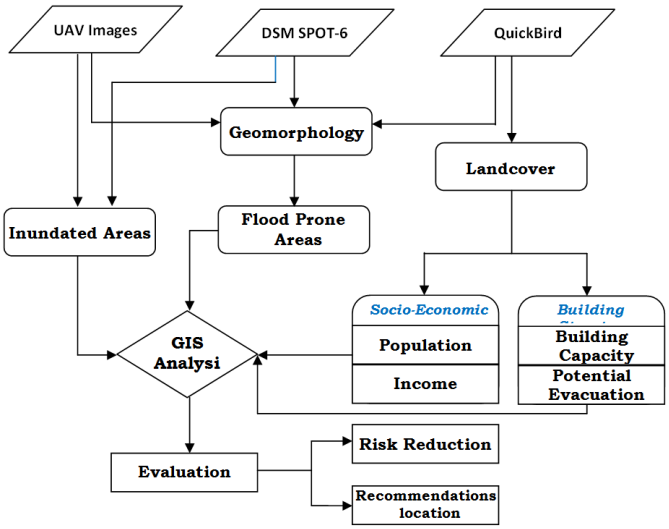

Figure 2-2: The flow of processing and data analysis

a. The study of the flood area of Kampung Pulo

Data SPOT-6 tristereo used to identify altitude in Kampung Pulo. This analysis is used to give a true picture of the elevation of the area, whether it is in a flood plain or not. Geomorphological analysis Kampung Pulo do. In addition UAV aerial photo data and QuickBird in 2010 is used to provide an overview of the condition of the buildings in the area of Kampung Pulo. Building vulnerability analysis carried out by the modification method performed by Sumaryono (2010).

b. Determination of inundation

Inundation area delineated by the UAV image data in 2013 and for the wider region in the estimation with DEM data extracted from the data SPOT-6 Tristereo to Kampung Pulo. This inundation conditions are actually due to flood conditions that obtained from direct UAV acquisition. Inundation areas are then used for analysis and estimation of how many people and critical infrastructure affected by the floods.

c. Calculation of the total population exposed to floods

Number of people exposed can be calculated from the estimated total building area and number of people as is done by Taubenbock, *et al.*, (2010) and also Qiu *et al.*, (2010). This method is based on the understanding that the urban morphology is a physical reflection of the society that created, which are influenced by historical, social, cultural, economic, political, demographic and natural conditions as well as their development. In a complex urban environment physically homogeneous pattern and the same type of building sector, structural alignments or similar building density can be localized and classified. This approach to semantic classification is generic, intended as a forward of any urban area in the world by using the available physical parameters are the same. In this approach used descriptive statistics values as Quartile (Q1, Q3), median (Med) or mean (M) to split the different classes.

Terminology semantic classes based on the quality of housing and location. The quality of housing is assumed to be higher with increasing the size of the high and low buildings or built-up density. In this approach classified six different semantic classes, namely 'shabby', 'Fringe', 'low class areas' (LC), 'middle class area' (MC) and the 'high grade areas' (HC). For each class we semantics assumes typical physical condition. For example, the slum is defined by the highest building density measured in an urban environment with mostly one-story building, the size of the smallest building.

In the implementation, the calculation in this approach among building area is linear with the number of inhabitants. The number of people exposed is calculated by how spacious the building located in the inundation area of UAV detected and estimated with DEM data SPOT-6 Tristereo.

d. Estimation socioeconomic conditions of residents of Kampung Pulo

Estimated social conditions can also be calculated from the results of a study conducted by Taubenbock et al. (2010) and Sumaryono (2010). This study links between socio-economic conditions of the population with characteristics and structures in the area of Kampung Pulo. Based on this, it can be analyzed socio-economic conditions in the floodwaters. Figure 2-3 is an example of the estimated socio-economic population with the condition of the structure and the type of buildings in a region.

e. Determination of vertical evacuation sites

Based on the results of the study on the condition of the study area,

floodplains, the number of people exposed, and the socio-economic conditions of the people in Kampung Pulo, it can be determined the location of vertical evacuation.

Bussiness areas

Slum areas

Town housing

Rural areas

Figure 2-3: The relationship between socio-economic conditions with the building structure

How capacity building that will be used for vertical evacuation can be calculated based on these results. Treatment of high socio-economic community would have been different with a low socio-economic levels. For example, the rich will be more free to leave home and stay at the hotel or relatives during flood events, while the poor will not be as easy as that. In determining the vertical evacuation sites in this study attention to these things.

f. Recommendations for flood disaster management

Recommendations flood disaster management in Kampung Pulo would be served if all the above steps have been performed. The cause flooding of the study the condition of the area, the number of people exposed, socio-economic conditions into consideration in determining the flood mitigation recommendations in the region. Recommendations were formulated based on qualitative spatial approach, by analyzing the qualitative spatial information of the condition of the area, the number of people exposed, as well as socio-economic conditions.

3 RESULTS AND DISCUSSION

3.1 Identification of areas prone to flooding

The research area is flooded regions, mainly in the rainy season. Based on geomorphological analysis using DEM data SPOT-6 Tristereo and UAV aerial photography, it is known that the study area is an area of the floodplain.

Identification landforms flood plains in urban areas such as research sites, it is difficult to do when only using QuickBird imagery and aerial photography. This is caused by the surface of the land that is not natural, experienced many changes into urban areas are filled with dense buildings. This will eliminate the surface conditions appearance bentangalam-natural appearance, especially fluvial landscape around rivers such as flood

plains, natural levee, meanders severed, and the marsh behind. However, using data from DEM SPOT-6 Tristereo, although on the surface have been many changes, but its natural landscape still identifiable by the expression topography. Thus, the boundaries of the landforms in the form of a flood plain that can easily be seen from the height of the pattern reflected from DEM data SPOT-6 Tristereo. Figure 3-1 shows the boundaries of landforms floodplain of the study sites (in red), analyzed data from SPOT-6 DEM and aerial photographs UAV, the pattern of the boundary between the inundation of flood water a brownish color with areas not affected by floods (colored lines dotted red), as well as the territorial boundaries of the floodplain landforms of the study sites (in red), verified by UAV aerial photo data.

3.2 Interpretation of Land Cover

Land cover research areas were analyzed visually by screen digitizing techniques (visual onscreen digitation) on UAV aerial photo data and QuickBird. QuickBird data is used as a complement to obtain information of land cover research areas are not recorded UAV aerial photography. Landcover of the study sites are classified into several classes, namely; built-up araes, roads, bareland, vegetation, and rivers. Buil-up areas class already includes a house (population), buildings (offices, schools, shops, factories, and public infrastructure). Class includes road pavement, concrete roads, and railroads. Generally bareland is vacant land that is not utilized or lands former building demolition. Vegetation covers urban forests, parks, yards, as well as the yard or lawn. While the river is surface water from the Ciliwung River. Figure 3-2 (a) shows the land cover information resulting from the interpretation.

The calculations show that the majority of Kampung Pulo is a building (105.06 ha, or 67.44% of the area). For vegetation makes up less than 10% of the total area. More fully, Table 3-1 shows the wide shows each class of land cover in Kampung Pulo. Vegetated land will serve as absorbing rainwater good. While undeveloped land has a low ability to absorb rainwater. Pay attention to the condition of the land cover, it can be seen that in the event of rain on the region, the most of the rain will turn into runoff and only a small portion is absorbed into the ground. Increased runoff of course will result in increased potential for flooding.

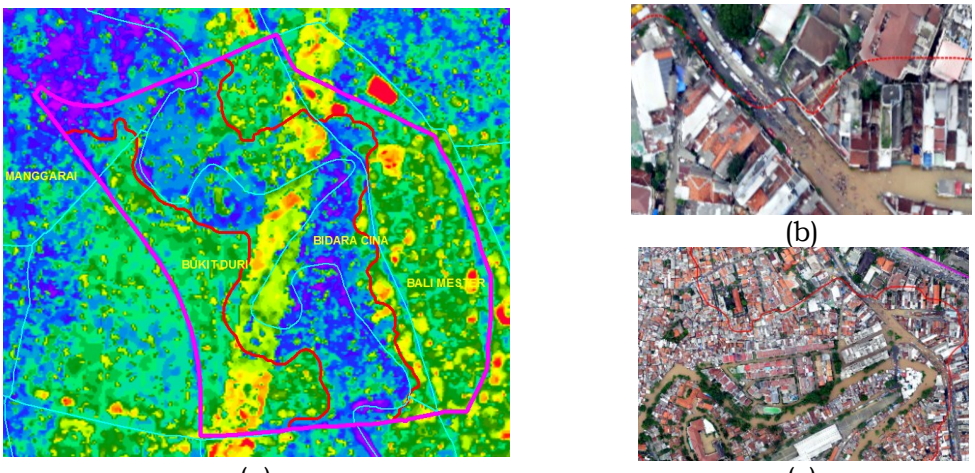

Figure 3-1: Boundaries floodplain landforms of the study sites (in red), analyzed data from SPOT-6 DEM and UAV aerial photography (a). The pattern of the boundary between the puddle of brownish flood in areas not subject to flooding (red line dotted) (b). Boundaries of the floodplain landforms of the study sites (in red), verified by UAV aerial photo data (c)

Table 3-1.: The area of Land cover

CLASS	SQUARE (Ha)	% SQUARE
Built-up	105.06	67.44
Road	21.58	13.85
Bareland	8.58	5.51
River	5.24	3.37
Vegetation	15.32	9.84
Total	155.78	100.00

3.3 Estimated Population

Estimates of the number of people carried by the model approach Qiu et al. (2010). Spatial distribution of the population in the study area can be seen in Figure 3-2 (b). In the image is clear spatial pattern of the population in Kampung Pulo. By based on BPS Jakarta Timur (2012), based on the number of population density in Sub Balimester and Bidara China which has an average density of 26,261 inhabitants/km^2, the number of people living in the study site is 40,909 inhabitants. Although the numbers were generated and reflected in Figure is estimated to over estimate, but most are not obtained complete picture of social conditions demographic Kampung Pulo.

3.4 Estimation of Socio-Economic Conditions

In general socio-economic conditions in Kampung Pulo can be categorized as low income and medium income, whereas a little proportion which has a high income. The estimation results of socio-economic conditions are presented spatially as shown in Figure 3-2 (c). Noting the picture, it can be seen that most of the residents in Kampung Pulo low income. The low level of income of this population will result in increasingly risky socio economic class of the society towards disaster.

3.5 Analysis of Potential Building Evacuation Sites

Analysis of potential building evacuation if the result if the comfort level expressed by 9 m2 in occupying the room, the estimated capacity of evacuation sites in Kampung Pulo only about 14,228 people. This condition indicates that when the number of people affected by the flooding exceeds that figure, it is necessary to provide more shelter locations outside Kampung Pulo. However, if the amount is less than 14,228, then in Kampung Pulo area still has the ability to accommodate the victims. Distribution of capacity building that can be used as evacuation sites are presented in Figure 3-2 (d). Based on these images in mind that the locations that can be used to accommodate victims in large numbers in the vertical evacuation effort is in the form of large-sized buildings such as offices, schools and shops.

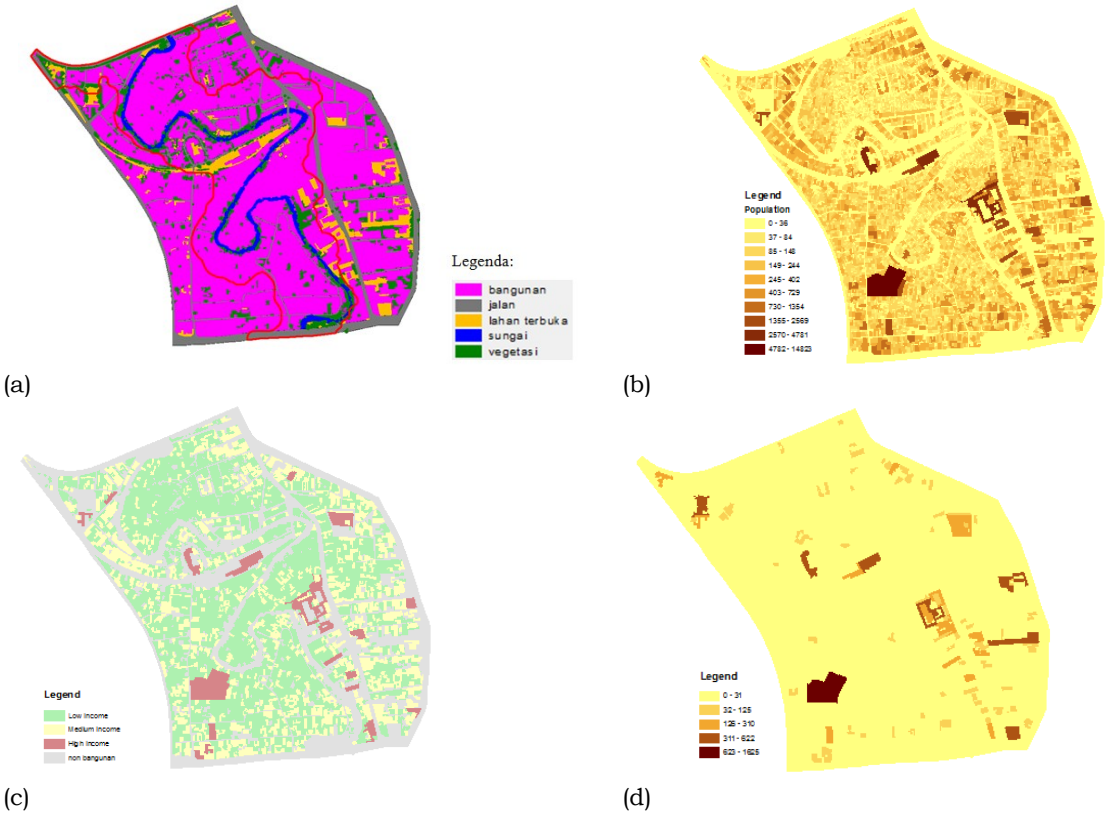

Figure 3-2: Land cover at the site of the research (a), estimate the spatial distribution of the population (b), the estimated distribution of socio-economic conditions (c), and the estimated capacity building that can be used for vertical evacuation

4 CONCLUSION

In geomorphology, Kampung Pulo is an area of the floodplain (floodplain), which is a flood-prone area periodically. Most of Kampung Pulo is a building that has a low ability to absorb rainwater so that in case of rain will be more easily cause flooding. The number of lots and dense population with largely have the lowest income levels (low income) show that people at risk for flooding. Capacity of Kampung Pulo as evacuation is about 14,228 people. if the number of people affected by the flooding exceeds that figure, it is necessary to provide more shelter locations outside Kampung Pulo. Locations that can be used to accommodate victims in large numbers in the vertical evacuation effort is in the form of large-sized buildings such as offices, schools and large shops. Based on the analysis it appears that in Kampung Pulo still needed additional buildings significant evacuation. Economic conditions seen in a low-medium income, so it needs special attention in society capacity building in flood disaster management.

ACKNOWLEDGEMENTS

The paper had previously been presented at the "Seminar Nasional Penginderaan Jauh Nasional 2014" and has been published in its proceeding. Some parts have been corrected for publication in the International Journal of Remote Sensing and Earth Sciences this. Thanks to the Head of the Technology and Data Remote Sensing Center LAPAN that has helped provide satellite remote sensing image data used in this study. Also the UAV team of Aviation Technology Center LAPAN that has helped provide data UAV aerial photographs of Kampung Pulo area during the flood emergency response efforts in the region.

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