Applied Geography 88 (2017) 174–185

Contents lists available at ScienceDirect

Applied Geography

journal homepage: www.elsevier.com/locate/apgeog

Utilising volunteered geographic information to assess resident's flood evacuation shelters. Case study: Jakarta

A.N.L. Kusumo [a, b, *], D. Reckien [b], J. Verplanke [b]

[a] Jakarta City Planning Department, Jakarta Capital City Government, Jakarta, Indonesia
[b] Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands

ARTICLE INFO

Article history:
Received 25 October 2016
Received in revised form
24 May 2017
Accepted 9 July 2017

Keywords:
Evacuation shelter
Flood
Volunteered geographic information
Jakarta

ABSTRACT

Research on disaster response frequently uses volunteered geographic information (VGI), due to its capability to provide near real-time information during and after a disaster. It is much less commonly used in spatial planning related to disaster management. However, VGI appears to have considerable potential for use in spatial planning and offers some advantages over traditional methods. For example, VGI can capture residents' preferences in a much faster, more timely, and more comprehensive fashion than is possible with, for example, questionnaires and surveys. This research investigates the usefulness of VGI for planning flood evacuation shelters. Using Jakarta, Indonesia, as a case study, we use VGI to capture the locations of flood evacuation shelters based on residents' preferences during flood periods in 2013–2014 and 2014–2015 and compare these with the locations of official shelters. Floods frequently affect Jakarta and the city administration uses VGI in flood emergency responses. Moreover, Jakarta has been identified as having the largest number of active Twitter users among cities worldwide. Thus, Jakarta is an appropriate place to study the use of VGI for planning evacuation shelters. VGI generated by Twitter users was used to identify the shelter locations preferred by Jakarta residents, and more precisely the flood evacuees. Of 171,046 tweets using keywords relating to flood evacuation, the content of 306 tweets indicated that they had been sent from inside or near evacuation shelters. The spatial pattern showed that those tweets were sent from 215 locations, mostly located near flooded areas. The analysis further showed that 35.6% of these shelter locations preferred by residents intersected with the locations of official evacuation shelters. As a general conclusion, our study demonstrates the advantages of using VGI for spatial planning, which mainly relates to the ease of capturing community preferences over a large area.

1. Introduction

1.1. Background

Social media have been acknowledged as key communication channels during situations of crises and disasters. Authorities and emergency response agencies use social media as a valuable source of information as well as a useful platform for the rapid delivery of information (Kreiner & Neubauer, 2012). It aids disaster responses and management before and during an event, e.g., by sending alerts, identifying critical needs, and focusing responses (Carley, Malik, Landwehr, Pfeffer, & Kowalchuck, 2015). Residents use social media to request help during a crisis, to share views and experiences on current topics, and to criticise responses by government agencies and other organisations (Takahashi, Tandoc, & Carmichael, 2015). Social media thereby allows residents to take part in the disaster response and management, as well as in other participatory processes (Goodchild, 2007).

Using social media, residents often voluntarily provide data on their own locations—known as Volunteered Geographic Information (VGI). VGI is made accessible by harnessing tools to assemble and disseminate these geographic data (Goodchild, 2007). VGI can aid disaster response and management (Takahashi, Tandoc, & Carmichael, 2015) by increasing the speed of interaction between victims and relief organisations. Some social media applications provide VGI, including Twitter, Flickr and Open Street Map which

* Corresponding author. Jalan Jatipadang Baru G-5, Pasarminggu, Jakarta 12540, Indonesia.
E-mail addresses: larasadya@gmail.com, adyaninggarlaras@gmail.com (A.N.L. Kusumo), d.reckien@utwente.nl (D. Reckien), j.verplanke@utwente.nl (J. Verplanke).

http://dx.doi.org/10.1016/j.apgeog.2017.07.002

have a geolocation feature (Schade et al., 2011). All these are used in situations requiring near real-time disaster response and management (Carley et al., 2015; Kreiner & Neubauer, 2012; Takahashi et al., 2015) before and during a disaster. However, VGI is rarely used in addressing spatial planning problems arising after an extreme weather event or disaster, relating to future disaster mitigation and/or climate change adaptation. VGI has considerable potential for such applications and appears to offer advantages over traditional methods. For example, VGI could be used for the planning of evacuation shelters, enabling residents' knowledge and preferences for shelters to be captured in a much faster, more timely, and comprehensive fashion than is possible with, for example, questionnaires and surveys.

The advantages of VGI are made use of in other case studies related to urban planning (Brabham, 2009), for instance with regard to people's participation on validating land use/cover in urban areas. Similarly, the endorsement of VGI by the government is also seen in many cases. Governments use VGI as a platform to accommodate reporting from the community. However, the use of VGI also has challenges (Johnson & Sieber, 2013), e.g. such as how to assure the validity of the data provided by the community.

This research investigates the advantages and disadvantages of using VGI for capturing residents' preferences for (official and unofficial) flood evacuation shelters and explores the usefulness of this information for urban planning. The research is motivated by the observation that official evacuation shelters provided by the authorities are not frequently used by the residents—a fact that is notified within the planning department of Jakarta for a long time (one of the authors is working there) and recognized by research since at least 30 years (Perry, 1979). Different factors determine people's use of official and non-official evacuation shelters (Stein, Duenas-Osorio, & Subramanian, 2010). According to Rahman, Mallick, Mondat, and Rahman (2014) these comprise drainage capacity, soils, technical feasibility, capacities, basic facilities, environmental impact, accessibility, land availability, and maintenance.

We address the objective mentioned above using Jakarta, Indonesia, as a case study. Flooding affects Jakarta on an almost annual basis. Moreover, authorities in Jakarta are forerunners in the use of social media, using Twitter to coordinate flood emergency responses. Jakarta itself has been identified as the city with the largest number of active Twitter users worldwide in a case study undertaken by Semiocast (2012). And Indonesia is recognized as the country with the most Twitter users, judged by the number of people visiting the site per month on a country basis (Smart Insights, 2015)—see also Appendix A. Jakarta provides an appropriate sample of Twitter users and flood emergencies and is therefore an appropriate and interesting case study.

The following subsection introduces Jakarta as case study and provides detailed information on previous flood events and the use of VGI in emergency responses. Section two provides information on the data, including data retrieval and processing, information on Twitter sampling and content analysis, and the use of secondary data. It also outlines the methodology. Section three presents the results, showing and analysing the locations of Twitter users during floods at or near official evacuation shelters. By superimposing this information on land use data we deduce people's preferences for certain shelter sites, providing a measure of the usefulness of the shelter sites. In section four, we discuss these results and reflect on the advantages and disadvantages of the VGI-assisted approach.

1.2. Case study

The study area for this research is the Province of Jakarta or "Special Capital Region of Jakarta" (DKI Jakarta), the capital of Indonesia (Fig. 1). Jakarta Province has a total area of 662 km^2 and comprises five administrative cities on the mainland and one administrative coastal region, covering the marine area and islands to the north of the mainland. Only the five administrative cities with their 267 sub-districts are considered in the research.

Flooding has been an issue in Jakarta since the colonial era. Based on historical records, major floods occurred in 1654, 1872, 1909, and 1918 (Team Mirah Sakethi, 2010). Currently, floods happen nearly every year. In 2002 and 2007 Jakarta was severely affected by two '50-year' floods (i.e., floods with a statistical probability of occurring once every 50 years). According to Firman, Surbakti, Idroes, and Simarmata (2011), the 2002 flood covered about one-fifth of Jakarta's total area. Hundreds of thousands of people were made homeless, 68 persons were killed, 190,000 people suffered from flood-related illnesses, and about 422,300 had to be evacuated. Flood losses were estimated at nine trillion Indonesian Rupiahs (USD 998 million) (Akmalah & Grigg, 2011).

The government of Jakarta province has incorporated the use of VGI in flood emergency responses, through an online resource known as "Peta Jakarta" provided by the Jakarta Government's Regional Disaster Management Agency (BPBD), in collaboration with the SMART Infrastructure Facilities, and Twitter. Peta Jakarta (@petajkt) is a system that utilises social media to gather, sort, and display information about flood events in Jakarta in real time (BPBD Jakarta, 2015). Jakarta's residents can also use the platform to report on conditions in their neighbourhood. Residents' reports may include information on flood events, evacuation processes, traffic jams, and other flood-related problems.

One of the reasons behind the development of the Peta Jakarta was the enormous volume of VGI being generated by residents of Jakarta through their use of social media. Based on research by Semiocast (2012), Jakarta holds the first place as the most active city using Twitter among all cities worldwide, based on the number of posted tweets in June 2012. A tweet is any message posted to Twitter which may contain photos, videos, links and up to 140 characters of text (see http://www.twitter.com). Semiocast analysed a sample of 10.6 billion public tweets posted by 517 million Twitter users. More than 2% of posted tweets came from Jakarta (Fig. 2.).

2. Data and methods

Our study adopts the following procedure to determine the usefulness of VGI data for planning evacuation shelters. *First, we* determine the location of Twitter users in or near evacuation shelters; *second,* the spatial pattern of users in or near evacuation shelters, and *third,* their preferences regarding the use of these shelters. To this end, the study employs secondary as well as primary data, which is analysed using various methods (Fig. 3.). In the following sections, we describe data retrieval, processing and analysis in more detail, following the three steps listed above.

2.1. Data retrieval and processing

This study used both primary and secondary data. Primary data was collected to determine the preferences of individuals (Twitter users) regarding shelters. However, due to a low response rate of the questionnaire aimed to determine information on location preferences also secondary data were used for preference elicitation. Secondary data comprise information on Twitter use, land use categories, and other spatially explicit GIS data from the statistical offices.

2.1.1. Twitter data

Twitter data was retrieved from the "Digital On-line Life and You" (DOLLY) archive—the massive database of geolocated Twitter data. The DOLLY Project is a repository of billions of geolocated tweets developed by "The Floating Sheep Team" that allows for