

The use of social media and open data in promoting civic co-management: case of Jakarta

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Abstract. With the high number of population and high use of social media, residents willingly share information in the digital world. While cities are sometimes seen as data-scarce, this digital platform produces informal and scattered, but also valuable data. One way to prepare for co-management during disaster situations is to extend these informal networks to include a channel between residents and government agencies. The platform PetaBencana.id crowd-sources these actual and on-ground observations from residents on social media and instant messaging, integrates the informal and formal disaster-related-data, gives the residents access to the same tool used by the government, and provides an interface that answers to residents and government's needs; thus making the information more useful in co-managing the city during disaster situation. More information-based decisions can be made by both the residents and government through improved situational knowledge, resulting in better disaster response and resilience of the city.

1. Introduction

In 2006, in its report, "The State of the World's Cities", the United Nations HABITAT office made a formal pronouncement that, for the first time, more than half of the world's population, nearly 3.3 billion, lived in urban agglomerations rather than in rural areas [1]. To conquer the challenge of expanding settlement and population in the cities, infrastructures are being built to ensure the life of the inhabitants, and finally, it becomes an unconscious part of the user, making urban life possible, according to Gandy (as cited in Furlong) [2]. Gandy [3] furthermore discusses that this condition is becoming the 'new normal' for residents in the city, thus, only in moments of crisis or failure do these complex and vulnerable systems come sharply into public view.

Computational systems, which enable the quantification and analysis necessary for understanding changing environmental conditions [4], are being developed to predict extreme weather events. However, the unpredicted disaster risk from failure of infrastructure is hard to be taken into account; in addition, megacities are often seen as data-scarce, which prohibits city managers and the people to not only respond to the emergency situation but also to do preventive efforts. How can we answer the needs of stakeholders and residents to make more informed decisions to foster resilience together? Through literature review and interviews of community, resident, and disaster managers, this paper will discuss the flood conditions and the power of social media in Jakarta, the applied research project—named PetaBencana.id—that harnesses the social and digital media to disseminate flood information in real-time, and how the open access of flood updates promotes civic co-management, both from residents and government, during disaster situation in the city. Flood report data and website traffic data used are sourced from PetaBencana.id usage during the February 2017 monsoon.

2. Jakarta: The City of Anthropocene

As the capital of the world's fourth most populous country, the megacity of Jakarta is by far the most densely populated city in Indonesia [5]. With over 30 million residents in the metropolitan area (known as "Jabodetabek"), Jakarta is also the second largest contiguous conurbation on earth[6]; meanwhile, the city has one of the highest concentrations of digital and social media usage in the world, generating 2.4% of



the world's tweets annually [7]. Jakarta is also home to 13 rivers and a complex system of hydrological infrastructure, and this megacity is also situated on a coastal edge of the world's most disaster prone region [8]. The residents have lived with seasonal flooding since at least the seventeenth century; while the global sea level has risen between ten and twenty five centimeters over the past 100 years [9], Jakarta's land has sunk by 1.5 meters just from 1999 to 2009 [10], with massive groundwater pumping as the main suspect on this land subsidence [11].

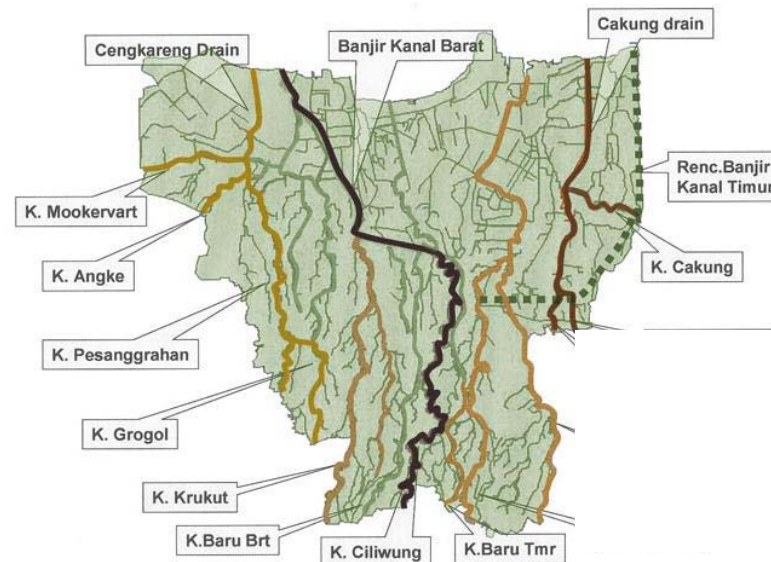


Figure 1. Major Rivers and Canals in Jakarta [12]

2.1. Floods in Jakarta

As a home for millions of residents and a complex system of infrastructure, and being located in the coast, Jakarta experienced flooding created by not only one particular cause. As analyzed by BPBD DKI Jakarta (Jakarta's Disaster Management Agency), there are three immediate manifestations of flood hazards in the city: 1) rain on the upstream area of rivers outside of Jakarta, which causes the overflow of rivers and macro-level hydrological infrastructures; 2) rain on the downstream or in Jakarta itself, which causes the overflow of drainages and micro-level hydrological infrastructures; 3) high tide, which causes a backflow of sea water to the northern part of Jakarta [13]. The upstream area of rivers in Jakarta itself is located outside the city, but in Puncak and Bogor, which are governed by different municipalities. As the river and flooding itself are located across administrative boundaries, different issues have contributed to the flooding, as discussed by Padawangi and Douglass, that not only global climate change affected the flooding, but also the intensity of human settlement manifested in covering land with non-porous materials, the sinking of cities due to excessive groundwater extraction, and changes in land uses in upland areas [14].

As residents in Jakarta are living side-by-side with seasonal floods, traditional ways of knowing the city or what we call "residential epistemologies" have been developed. Particularly with floods, residents have built an informal system to both predict and prepare for the arrival of seasonal flooding. Among the grassroots communities, they developed a communication system to alert people living along Ciliwung River, so that the community located in the upstream in Katulampa will alert the people in the lower area. With this system, they developed a knowledge of predicting and preparing for the flood; if the water has been rising to a certain level or the rain has come for certain hours in Katulampa, it will reach the city in certain hours. Cited from Abdul Kodir and Teja from Ciliwung Institute [15], this created a chain until the information reached people in the downstream area, giving them sufficient information to predict and prepare for the upcoming floods. Furthermore, a resident on the riverside of Ciliwung [15] explained how

residents in the downstream area, for example in Bukit Duri and Kampung Pulo, also developed a knowledge system for anticipating the floods. As Kampung Pulo is lower than Bukit Duri and located on the other side of the river, people in Bukit Duri will start to evacuate or move their furniture up if the water reaches the second floor of houses in Kampung Pulo, as it means it will reach their houses soon. This knowledge is developed throughout time and consisted of a combination of experiences and senses in their relation to the river and floods.

However, these residential epistemologies have been disrupted due to unpredictable weather patterns leading to infrastructural changes. Climate change has increased concerns about flooding in Jakarta, as unusual torrential rains and more frequent tidal floods [16] are becoming familiar phenomenon. Competing infrastructural interventions to the already complex systems of hydraulic and hydrological infrastructures compound the difficulty of anticipating the flood. Floods have been the most destructive disaster and growing worse with the increasing population and extensive development along the years; the floods of 1996, 2002, 2007, and 2013 were the greatest and most destructive in the city's history, reported by GFDRR as cited by Padawangi and Douglass [14]. In 2007, 75 percent of the city was flooded and 430,000 people were displaced from their homes with direct estimated economic costs on infrastructure and assets of more than US \$900 million [14].

While infrastructure development throughout the city includes the means to anticipate the flood, there is the growing vulnerability of the infrastructure itself. In 2013, the flood was unusual and reached the central landmark of the city, Bunderan HI, due to an unexpected canal breaking within 1 km from the landmark. Padawangi and Douglass [14] explain that while the 2007 flood episode was mostly due to excessive rain, the overall pattern of floods in 2013 approximates the flooding of 2007 and affected the flood-prone settlements in coastal areas and along rivers. This flood episode caused 11 fatalities and at least 20,000 residents were displaced from their homes [17].



Figure 2. Flooding in Jakarta's Central Business District and Bunderan HI in 2013 [18]

The vast project of infrastructure construction has changed the existing residential epistemologies within a short time. Since the river wall construction—popularly known as '*normalisasi*'—started, the relationship between the river and people living alongside it has changed; people could not monitor the changes of water on the river since the wall is built over the eye level. The combination of the diverse infrastructure projects throughout the city—including waterproofing the city with a giant sea wall—and erratic rain patterns due to climate change have debatably changed the way flooding arrives, as now residents sensed it is now more often but far less severe. As a resident quoted during an interview [15], *"...Before, they had big floods, perhaps 3 times a year for a few days, now it is almost every week but only goes up to the ankles."* The construction of infrastructures is also changing the flood-risk perception, as noted by Timothy Forsyth (cited by Padawangi and Douglass) [14]: *"... Once new infrastructure is in place, land areas that are presumably safer from floods become more attractive as sites for projects*

directed toward affluent users and consumers. These engineering projects for flood mitigation, presented as scientifically sound solutions without acknowledging the relations of power that drive them, can be detrimental to marginalized livelihoods and may even increase environmental degradation.” With the vast changes of the city and behavior of floods, both the government and residents need more real-time information in anticipating the floods.

2.2 Social media usage in Jakarta

In Indonesia, a vast expansion of ICT infrastructure is underway, followed by a social network of information that is realized in its wake. In 2017, Indonesia has the highest growth rate for internet penetration, with 51% year-on-year growth [19]. With approximately 10% in the country’s population concentrated in Jakarta, the image of the city, and the nation, is being shaped by digital platforms which act as central nodes for the dissemination and curation of information and trending topics.

Simultaneously, the ubiquity of Internet-connected mobile devices has transformed methods and possibilities of participation in urban life. These smartphones—which actually function as *portable computers*—bring applications to the migrating masses, and more importantly, connect the whole city, rich and poor, to the internet [19]. In 2016, Indonesia was claimed as the third biggest smartphone market in the Asia Pacific region [20]; in 2017, mobile connections are listed at 142% of the country’s population [19]. Roughly, 35% of the Indonesian population accessed social media from mobile devices in 2017—that is, about 80 million people used smartphones to connect and exchange with one another.

With data now operationalized as a new form of currency, information is becoming a new kind of power. The expansion of Internet penetration in Indonesia reached 51% of the population in 2017, just slightly higher than the global average [19]. One of the characteristics of Indonesian people is that we really like to share information, whether as an act of service, or as a form of self-actualization, we are enthralled with freedom of expression. Thus, 41% of the population has social media accounts and Indonesia has the most Facebook users: 106 million users, or 6% of the total active users.

3. Civic co-management goes digital

During disaster situations, Jakarta’s residents tend to self-organize and inform each other. This habit started in the 19th century, when people used a traditional type of bell and clapper made from wood, called a *kentungan*. Assigned residents would use the *kentungan* to let the others know if the water started rising, especially if this occurred during the night. Today, as discussed before on Section 2, communities along the Ciliwung River build informal SMS chains to inform one another about the water heights and river gauges nearby their houses. That way, downstream residents can know approximately when the water will arrive in their neighborhood, and thus have more time to evacuate families and move valuable goods.

By 2050, studies estimate that over 200 million people globally will be forced to flee due to the sea level rise [21]. Yet, each year tens of thousands of people are moving to Jakarta, the flood-prone coastal area that is already overwhelmed by the pressures of urbanization. As the global discourse about climate change moves from concerns over “sustainability” to issues of “resilience,” the co-management of migration could actually help to transform neighborhoods and communities into a more diverse and resilient society.

3.1 The role of social media in disaster management

With the high number of population and high use of social media, residents willingly share information in the digital world. While cities sometimes are seen as data-scarce, this digital platform produces informal and scattered, but also valuable data. One way to prepare for co-management during disaster situations is to extend these informal networks to include a channel between residents and government agencies. With the ubiquity of GPS-embedded smartphones, people can share updates in real time, including their geolocation, via social media and instant messaging. Unlike traditional media, social media relies on user-generated content, which refers to any content that has been created by end users or the general public as opposed to professionals. As the numbers of users has increased, there has been a growing interest in

applying social media to address national priorities, not just using them for entertainment or corporate purposes, as discussed by Priolli, Preece, & Shneiderman in Bertot et al. [22].

Government employment of social media offers several key opportunities: democratic participation and engagement to foster participatory dialogue and providing a voice in discussions of policy development and implementation; co-production between the government and the public to jointly develop, design, and deliver public services; seeking innovation through crowdsourcing public knowledge and talent to develop innovative solutions [22]. A study done on local government usage of social media by G. Moss et al. in UK outlined four main organizational purposes that social media and its analytics might serve: communication, public relations, customer services, and public consultation and engagement; all of which involve making ‘the public’ present to the organization in different ways and with different potential implications and effects [23]. Knox in 2013 discusses that while there is potential to increase legitimacy through involvement, collaboration and dialogue, there are also difficulties with accommodating large flows of direct public feedback into public organizations [24].

As the provider of public services, the government is expected by its public to apply its assets to provide relief and assistance in disaster. Regardless of community size or the nature of disaster, local government leaders are responsible for overseeing all four phases of emergency management: preparedness, response, recovery, and mitigation, while federal and state governments play a supporting role in the immediate aftermath and in providing funding and guidance for long-term recovery and mitigation [25]; however, with their limitation and bounds, government agencies could not work alone in disaster management.

The use of social media in recent disasters (e.g., 2010 Haiti earthquake, 2011 Japan earthquake) around the world has been well documented, and some researches such as Yates and Paquette in 2010 even suggest that “disaster response may be the ideal environment for ‘proving the worth’ of social media as a serious knowledge management platform” [26]. Neil Duffy further discusses that social media have already demonstrated their use in the emergency management field, but also have potential in the field of disaster risk reduction and community development, as social media can easily form ‘communities of practice’ before, during, and after the event. In disaster risk reduction field, social media can help people understand the residual disaster risks in their communities and what is being done to manage this risk [26]. In emergency management field, the main goal is to ensure community safety through ‘shared responsibility’, in the context that communities, individuals and households need to take greater responsibility for their own safety and to act on advice and other cues given to them by state and local government agencies. By the nature, social media can build emergency management communities of interests that share responsibilities, as they rely on peer-to-peer networks that are collaborative, decentralized, and community driven [26]. Social media have made it simpler to interact with others without the limitations of geography and lack of time, therefore, can encourage and sustain learning communities [27].

3.2. *PetaBencana.id: real-time flood mapping*

Jakarta’s love of social media is best exemplified with its Twitter users’ posts—2.4% percent of global tweets are coming from Jakarta [7]. With the habit of sharing via social media, people can disseminate time-critical updates and photos of the flood situations. Based on Twitter #DataGrant (2013), there were over 150,000 tweets with geo-locations containing the word *flood* or ‘*banjir*’ in Jakarta and its metropolitan area during 2013-2014, showing that residents are the best sensors of the city. By sharing their updates, they are providing real-time updates and actual on-ground observation of their surroundings, which can be further leveraged for stakeholders in decision-making process.

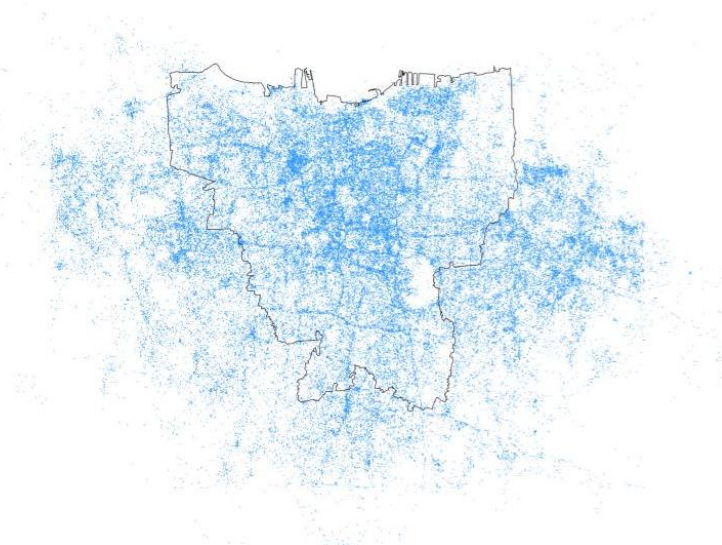


Figure 3. Map of tweets from Twitter #DataGrant containing the word “flood” or “banjir” in Jabodetabek area, each represented by blue dot, during monsoon floods in 2014 [28]

Harnessing the power of social media in Jakarta, PetaBencana.id supports a digital information-sharing ecosystem during flood. Residents can easily describe their situations, include selfies, and as the tweet is geo-referenced, PetaBencana.id uses an open source software named CognitionCity OSS to map the tweets and share them through a publicly accessible map. This map functions as a decision-making support for residents to evacuate and navigate through the city during flood, and for government agencies to take an action in response to life-threatening situations. This social media power inspires PetaBencana.id to adopt a “people as sensors” paradigm, where reports are collected directly from the users, or crowd-sourcing, at street level in a manner that removes expensive and time-consuming data processing.

This method of crowd-sourcing answers the limitation of data collection during disaster situation. Limitations of conventional sensors restrain the collection of real time and street level data, which is critical for emergency response. As conventional sensors are mostly needed to be located in static places, it needs regular maintenance to be able to provide real-time data, and the data collection is limited to the number of sensors available in the city while stakeholders need to get an overview of the emergency situation comprehensively in a short time.

3.3 Perspective of residents

By sharing this critical and valuable information, PetaBencana.id aims to democratize decision support and de-credentialize local reporting during emergency situation in floods, as any resident can report and access the flood report map by only connecting to the Internet. When the actual updates of flood situations are shared, not only city stakeholders can use it as a decision support for managing disaster situations, but this will also help residents in making their decisions in organizing themselves during these critical times, thus democratizing real-time and actual information of the floods as a decision support for the public.

Enabling people to report through social media, as well, de-credentializes the local reporting system in disasters, as reports collected from the residents are coming from the street level and help first responders to grasp the current situation in a short time and eliminate the need for time-consuming data collection in disasters. In this manner, interaction among residents and between residents and stakeholders are encouraged, without certain qualifications or eligibility criteria. Most importantly, the main victim of disaster is the people, so the best “sensors” of disaster are the people themselves. Sensors in rivers and canals are still important to measure the water level, but the senses collected from the people are the most

important data; by sharing what they see, experience, or need during the flood, people can be a reliable source, and that can be done through the most ubiquitous way: mobile use of social media.



Figure 4. Interactive flood cards designed to guide users to input flood updates via PetaBencana.id. From left to right: location confirmation, input flood height, submit picture, describe the situation, submission confirmation, and users will be redirected to the public map to see their report [29]

CogniCity OSS and PetaBencana.id are adapting to receive more information from apps, making the platform medium-agnostic. Based on the behavior of app usage, as people are deeply engaged to their favorite apps, imagine the situation during disasters; people would look for information more intensely within those apps during their mobile usage and reintroducing them to use new apps with new functions and interface would be an ineffective way [30]. Instead, PetaBencana.id chooses to integrate with other local reporting apps and citizen journalism apps and connect to instant messaging platforms. Reports can be shared to private or group chats in messaging apps, making the information of flooded locations circulate easily.

To report the flood through Twitter and Telegram, residents can call the report link by tweeting #banjir to @petabencana or sending text /banjir to @BencanaBot on Telegram. BencanaBot will reply with a link to the report cards, and users will be guided to submit a report through 3 easy steps: confirm the location on the map, input flood height, submit picture and/or include text description, as shown in Figure 4. These flood cards—acting as a micro-survey tool—collects important information on the disaster, thus the user experience (UX) was designed to correspond with residents’ interaction with the flood in the city. The second picture in Figure 4 or the “input flood height” card shows a comparison of an average car height and adult height. Users can input the flood height via the interactive slider while comparing the flood height with car or adult height, as the important message of this information is to tell the others that whether the road is passable by vehicle or how safe it is for the people to stay.

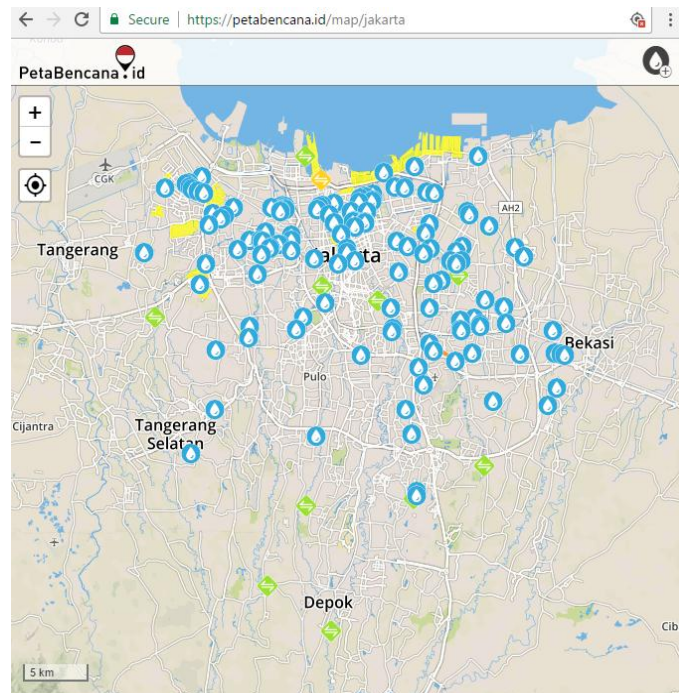


Figure 5. Screenshot of <https://petabencana.id/map/jakarta> on February 21st, 2017, 8:09 am Jakarta time. Each water drop icon represents a flood report from the user [29]

After the flood report is successfully submitted by the user, user will be directed to the map to see their submitted report, as this sends a message that the user has contributed by sharing valuable information. The freely accessible map of real-time flood reports—available on <https://www.petabencana.id/>—is designed to be loaded lightly on mobile browsers, thus residents can easily use it on mobile devices during floods to help them make informed decisions on navigation or evacuation. This UI/UX were designed to provide the interface needs to make the city and the happening flood sensible for the residents throughout the city, resembling that users can affect the city and floods and be affected by them [4].

During the last monsoon in 2017, a big flood happened on February 21-22. During that time the residents in Jakarta and the greater metropolitan area actively reported flood in their neighborhood; more than 1,000 reports of flood were received and displayed in real-time on the PetaBencana.id map, which was accessed by more than 250,000 users. These reports were used to help drivers navigate the city during flood - one online taxi company, Uber, promoted the map to its drivers.

Table 1. Statistics of reports and website traffic of PetaBencana.id during the flood in February 21st 00:00 until February 22nd 23:59, 2017. [29]

Reports	
Total Reports Received	1,135
Reports from Qlue	876
Reports from Twitter & Telegram	223
Reports from PasangMata	36
Website Traffic	
Sessions (total times viewed)	312,794
Users	252,449
Pageviews	373,591
Website User Device Type	
Mobile	83.79%
Desktop (including laptop and notebook)	14.69%
Tablet	1.51%

From 223 reports we received through Twitter & Telegram on February 21-22 as shown in Table 1, 171 reports contained pictures of the flood situation. 203 reports containing text descriptions of the flood situation were analyzed using content analysis method.

Table 2. Content analysis of texts in reports of February 21-22, 2017 [29]

Content	Sample Report (translated)	Count of Reports	Percentage
Mentions specific location	<i>"Flood about 100 cm, at Jl. Penegak Raya"</i>	115	56.72%
Includes water depth	<i>"Already enter the house 7 cm"</i>	68	33.83%
Describes changes over time	<i>"Flooded since 05.00, raising until now"</i>	31	15.42%
Mentions of flood reason	<i>"Flood in this road, because the drainage is not that deep"</i>	26	12.93%
Mentions time flood started	<i>"Started to flood at 9 am"</i>	21	10.45%
Mentions hydro infrastructure	<i>"There are 2 pumps but only 1 pump works. please repair it soon to help recedes the water"</i>	18	8.95%
Alerts others to risk	<i>"Flood in bekasi, be aware of disaster"</i>	17	8.45%
Mentions rain	<i>"If there is rain it is always flooding"</i>	16	7.96%
Request for help	<i>"Please help to dry it sooner"</i>	14	5.97%
Mentions traffic situation	<i>"Flood in pedongkelan area, vehicles can't pass"</i>	10	4.98%
Summons government	<i>"... Please do something, government! It's very disturbing and I am not living here for free"</i>	3	1.49%

Based on the text content, users are providing information that is valuable for other residents to avoid the flood. Most of the description (56.72%) contains specific location of street or physical landmark even though users were guided to confirm the location by pinpoint on the map on the first flood card. Other markers such as water depth (33.83%), related hydro infrastructure (8.95%), and traffic situation (4.98%) are also used by users who report to warn other residents, in addition to messages directly alerting others to risk (8.45%). As this platform is also freely accessible for government use and disaster relief agencies, the description is functioning as a way to communicate with these agencies. Users put some more detailed aspects to direct disaster managers to help, such as changes of flood over time (15.42%), the timeframe of

flood start (10.45%), request for help (5.97%), even directly summoning the government (1.49%). Some reports also contained description of the cause of the flood: direct mention of rain (7.96%) or other related reasons (12.93%), showing that residents know best about their surroundings and thus can better inform others about their situation.

By crowd-sourcing flood information from the residents, the actual and on-ground updates on flood can be collected in a non-time-consuming manner. By integrating these informal but valuable reports with a detailed map of the city and critical infrastructure data from formal agencies, then sharing it openly via a publicly accessible map, civic co-management can be promoted and residents can make more independent decisions on safety and navigation in response to the flood in real-time. Now that the residents have the updated information on floods despite their limited resources, we move to the next question: how can the government leverage this tool for disaster response?

3.4 Government perspectives

From 2014 to 2016, PetaJakarta.org (the pilot project which preceded PetaBencana.id) was used by the Jakarta Disaster Management Agency (BPBD DKI Jakarta) to monitor the flood situation and improve response time for the first responders. The success of this pilot project was monitored by the National Disaster Management Authority (BNPB), which then promotes the development of this platform to a greater area, as the development of a platform with the basis of social media and digital media enables people to report easily and in real time; a disaster is everybody's business so the people need to be involved in sharing the information of their needs in time of pre-disaster, during disaster, and post-disaster. The spokesperson of BNPB, Dr. Sutopo Nugroho [15] stated that the behavior of the Indonesian people who willingly share information can be used by the government to do their task better: to provide and meet public needs to support residents' preparedness during disaster. It is harder for the higher level of government to wait for reports from local authorities due to bureaucracy; with information from the public, the government will know the real situation and what the public needs.

As the government is one of the main stakeholders in disaster management and has more resource for first responders, PetaBencana.id is designed as a platform to support decision making and dynamic communication between the government and residents. The Command Center of BPBD DKI Jakarta uses the platform to monitor the floods especially during monsoon season and to support the decision-making process for first aid response. Distribution of government staff is beneficial to help verify the flood information, which can be shared to residents in a public map, via a government interface or dashboard, called a Risk Evaluation Matrix (REM).

Before PetaJakarta.org established, the erstwhile official flood updates from government were issued through text messages and the official map is published in a portable document format (PDF) as shown in Figure 6. As these official updates were issued in 6-hour periods, the updates were used mostly for curative efforts, rather than acting as real-time information for disaster response and for communicating with residents to avoid bigger risk. Through PetaBencana.id, these verified flood heights or official updates from the Command Center is being put via REM, by activating a color-coded menu on particular community group boundaries—named Rukun Warga (RW) and extending around 25 ha on average in Jakarta—on the map. The color code marks the water depth ranged from 10-70 cm, 71-150 cm, and >150 cm flood. This official information is shown in real-time on the public map; thus, the flood map acts as a communication medium to give the residents the verified flood status from the government. While the intention of democratizing decision support has not been changed since the usage of the erstwhile PDF flood map, giving residents access to the same tool used by the government and changing the format to an easily readable map that relates to the residents' needs would make the information more useful for the residents.

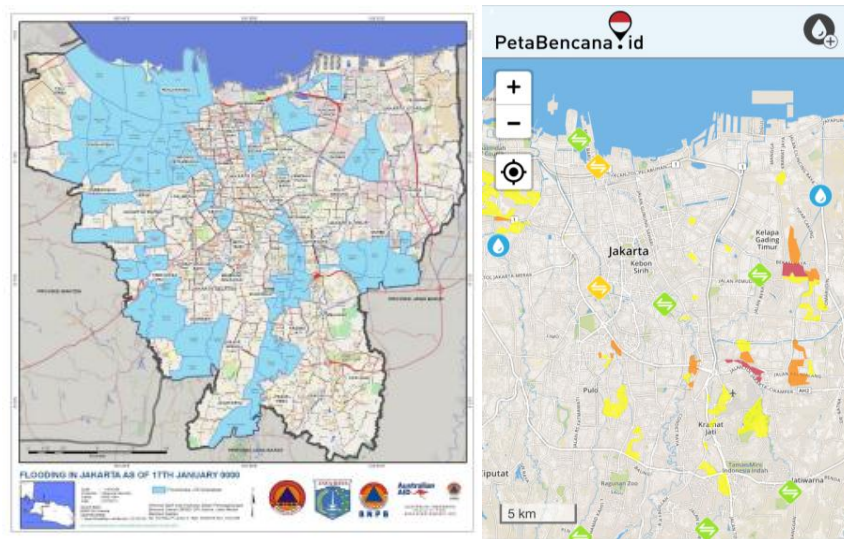


Figure 6. Comparison between flood map PDF used by BPBD DKI Jakarta before PetaJakarta.org (left) and screenshot of official flood updates on PetaBencana.id map, February 21st, 2017 (right) [29]

Table 3. Color codes of flood classification and number of flood polygons (flood affected RWs) activated by BPBD DKI Jakarta during flood in February 21-22 [29]

Flood Classification	Feb 21 st			Feb 22 nd		
	04:00-08:00	08:00-12:00	20:00-00:00	04:00-08:00	08:00-12:00	20:00-00:00
Use Cautions	0	3	0	1	2	1
10-70 cm flood	39	151	63	119	90	11
71-150 cm flood	4	8	13	23	16	0
>150 cm flood	0	0	0	7	7	0
Total	43	162	76	150	115	12

Not only the user interface should be concerned, but the server capacity is also important as the population of Jakarta is reaching almost 10 million people. In order to handle the spike in web-traffic on February 21st, PetaBencana.id scaled to up to 8 servers. The capacity to scale at the Elastic Beanstalk layer meant that the underlying database only experienced a small increase in CPU load. Importantly, while the websites of all other government and local agencies responsible for disseminating emergency information crashed under the heavy traffic, PetaBencana.id was the only platform that remained consistently functional; testifying the amplified capacities of multi-stable, multi-scalar, and multi-dimensional computational architectures. More importantly, the map was used as a reference for Governor of Jakarta province to deploy the field officers to help drying the flood and making sure the residents were safe [31].

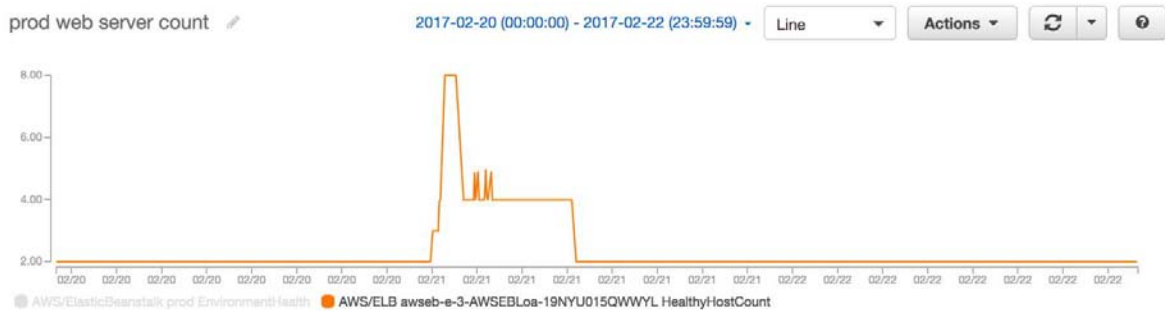


Figure 7. PetaBencana.id web server count graph showing that on February 21st, 2017, the web server scaled up to 8 servers [29]

Having a two-way communication during disaster situation is a new challenge to the government of Jakarta. Jakarta Disaster Management Agency (BPBD), involved in the development of PetaJakarta.org since 2014, stated that PetaJakarta.org was a new breakthrough [32]; it began when the agency needed real-time information as they did not have enough sensors to detect the flood height in the city, aside from the water level sensors in the river. The information from citizens is gathered through PetaJakarta.org, and will be verified through REM, thus acting as a flood map, both used internally within the agency or as information for other agencies and for residents. Moreover, BPBD and PetaJakarta.org team trained the head of villages or *Lurah* in 5 cities in Jakarta to report and use the flood map; therefore, after the command center of BPBD updates the official information of flood through REM, the agency expects the head of villages to respond on the flood.

With the existence of the platform, there is citizen support enabled by this framework. BPBD noticed that residents are being more interactive than before to give information about flood, and at the same time the agency tends to be more open to share information, as the agency always emphasizes data transparency. Upon creating an information-sharing environment on flood with this platform, there is a pressure felt by BPBD created from public expectation; however, it is also felt as an advantage for the agency, as they will know immediately about the flood situation in the city and could act faster [15]. On the other hand, BPBD as disaster managers hope that they can do disaster response together with the residents. When people share information to each other, along with that, their awareness of flood threat will increase. BPBD noticed that since PetaJakarta.org was established, people started to be aware of disaster information; back then, they ignored the warnings. It can be seen when the command center was late to share the weather forecast, the residents would start to comment ‘where is today’s weather forecast?’ [15]

The agency hopes to raise the concern and caring among each other; that is their main purpose, so people can help each other. The government’s long-term mission is to start delegating the authority of disaster management, so that it would not only come from the government, but also non-government agencies (private sector, NGO, and citizens), so when disaster happens they are aware and do the first response autonomously. This condition is more sustainable than only waiting for the government to help the people; if there is any severe flooding, they hope people who know about the flood anywhere can also help the others [15]. To support this, PetaJakarta.org and later PetaBencana.id also share and visualize critical infrastructure data collected by the government alongside the reports, to help government agencies and residents anticipate the potential of incoming floods. More information-based decisions can be made by government agencies in Jakarta through improved situational knowledge; therefore, increasing resilience of the city to flooding and its attendant difficulties and fostering equitable climate change adaptation.

Operating in an open-data environment, the reports and verified polygons in PetaBencana.id can be downloaded through an open API for further use of research and development. The data is not only used by other non-governmental organizations, but also BPBD DKI Jakarta to assess the damage and loss with

other software and also synchronize the data with other agencies, e.g., Agency of Public Works, Planning Agency, and Spatial Agency for future planning [13].

4. Conclusion

In co-managing the city during a disaster situation, the need of actual and real-time disaster information in megacities like Jakarta can be answered by crowd-sourcing the information from residents via social media and instant messaging. This valuable information can be harnessed by residents and the government to make more informed decisions. It is important to note that achieving disaster resilience is not solely the responsibility of emergency management agencies, but a shared responsibility across the society; therefore, disaster managers and first responders, especially local government units in Jakarta, should work together to improve emergency management and advisory roles. Providing reliable information for residents should not be seen as an incompetence of the government in managing the disaster; moreover, the government should communicate the up-to-date situation to residents, so residents can use the information provided as their base of action for their own safety in the event of disaster and to avoid residual risks. Integrating the informal and formal data source, giving residents access to the same tool used by the government, and designing the interface that relates to residents' and the government's needs are important to make the information more useful in democratizing decision support, to create a multiplying effect of valuable information in disaster situation. Better evidence-based decisions are made through accessible situational knowledge, resulting in better disaster response and resilience in the city.

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References

- [1] Soja E and Kanai M 2014 *The urbanization of the world in Implosions/explosions: Towards a study of planetary urbanization* ed Brenner N (Berlin: jovis Verlag GmbH) pp 142-159
- [2] Furlong K 2010 Small technologies, big change: Rethinking infrastructure through STS and geography *Progress in Human Geography* **35** 460-482
- [3] Gandy M 2012 *Where does the city end? in Implosions/Explosions: Towards a study of planetary urbanization* ed Brenner N (Berlin: jovis Verlag GmbH) pp 86-89
- [4] Bratton B 2015 *The stack | on software and sovereignty* (Cambridge: MIT Press)
- [5] Worldometers 2017 Countries in the world by population (2017) *Worldometers* [Online]. Available from: <http://www.worldometers.info/world-population/population-by-country/>
- [6] Cox W 2015 Largest 1,000 cities on earth: World urban areas: 2015 edition *New Geography* [Online]. Available from: <http://www.newgeography.com/content/004841-largest-1000-cities-earth-world-urban-areas-2015-edition>
- [7] Aly W 2013 Welcome to Jakarta, the world's number one Twitter city *RN Drive* [Online]. Available from: <http://www.abc.net.au/radionational/programs/drive/social-media-in-indonesia/4720678>
- [8] Turpin E, Bobbette AW, and Miller M 2013 Introduction: Who does Jakarta think it is? in *Jakarta: Architecture + Adaptation* (Depok: Universitas Indonesia Press) pp 2-58
- [9] UNEP 2017 Vital climate graphics: Observed climate trends *GRID-Arendal* [Online]. Available from: <http://old.grida.no/climate/vital/19.htm>
- [10] Prameshwari P 2009 The tides efforts never end to repel an invading sea *JakartaGlobe* [Online]. Available from: <http://jakartaglobe.id/archive/the-tides-effortsnever-end-to-repel-an-invading-sea/>

- [11] Abdurrahman O 2014 Air tanah Jakarta: Air diambil, angka dicatat *GeoMagz* [Online]. Available from: <http://geomagz.geologi.esdm.go.id/air-tanah-jakarta-air-diambil-angka-dicatat/>
- [12] Dinas Pekerjaan Umum Provinsi DKI Jakarta 2018 [Online]. Available from: http://www.serverjakarta.com/peta_13sungai.aspx
- [13] BPBD DKI Jakarta 2017 *Sistem informasi bahaya banjir di Provinsi DKI Jakarta, Presentation by BPBD DKI Jakarta* (Jakarta: BPBD DKI Jakarta)
- [14] Padawangi R and Douglass M 2015 Water, water everywhere: toward participatory solutions to chronic urban flooding in Jakarta *Pacific Affairs* **88** 517-550
- [15] PetaBencana.id 2017 *The Same River, Twice* (Documentary exhibited in Lisbon: The New Art Fest)
- [16] Desyani A 2013 Jokowi pantau lokasi banjir rob Pademangan *Tempo.co* [Online]. Available from: <https://metro.tempo.co/read/488850/jokowi-pantau-lokasi-banjir-rob-pademangan>
- [17] Leoni B 2013 Indonesia declares state of emergency in wake of heavy floods *UNISDR* [Online]. Available from <https://www.unisdr.org/archive/30593>
- [18] Munns L 2013 Photo shared by Twitter user @LukeMunns [Online]. Available from: <https://twitter.com/lukemunns>
- [19] Kemp S 2017 Digital in 2017: Global overview *We Are Social* [Online]. Available from: <https://wearesocial.com/special-reports/digital-in-2017-global-overview>
- [20] eMarketer 2016 Indonesia is the 3rd-largest smartphone market in the Asia *Pacific Indonesia-Investments* [Online]. Available from: <http://www.indonesiainvestments.com/news/todays-headlines/indonesia-is-the-3rd-largest-smartphone-market-in-the-asia-pacific/item6777>
- [21] Kamal B 2017 Climate migrants might reach one billion by 2050 *ReliefWeb* [Online]. Available from: <https://reliefweb.int/report/world/climate-migrants-might-reach-one-billion-2050>
- [22] Bertot JC, Jaeger PT, Hansen D 2012 The impact of policies on government social media usage: Issues, challenges, and recommendations *Government Information Quarterly* **29** 30-40
- [23] Moss G, Kennedy H, Moshonas S, Birchall C 2015 Knowing your publics: The use of social media analytics in local government *Information Polity* **20** 287-298
- [24] Djerf-Pierre M, Pierre J 2016 Mediatised local government: Social media activity and media strategies among local government officials 1989-2010 *Policy & Politics* **44** 59-77
- [25] Becker C 2009 Disaster recovery: A local government responsibility *Public Management* [Online]. Available from: <http://ICMA.org/pm>
- [26] Dufty N 2012 Using social media to build community disaster resilience *Australian Journal of Emergency Management* **27** 40-45
- [27] Tibbitt J 2011 Social media, social capital and learning communities *PASCAL International Observatory*
- [28] Data Grant 2015 “Flood” or “banjir” in Jabodetabek area during monsoon floods in 2014 [Online]. Available from: <https://PetaJakarta.org>
- [29] PetaBencana.id 2017 Peta Bencana Indonesia [Online] Available from: <https://PetaBencana.id>
- [30] Perez S 2015 Consumers spend 85% of time on smartphone in apps, but only 5 apps see heavy use *TechCrunch* [Online]. Available from: <https://techcrunch.com/2015/06/22/consumers-spend-85-of-time-on-smartphones-in-apps-but-only-5-apps-see-heavy-use/>
- [31] Kurniawan T 2017 Ahok pamer bukti banjir cepat surut *MetroTVNews.com* [Online]. Available from: <http://news.metrotvnews.com/read/2017/02/23/662355/ahok-pamer-bukti-banjir-cepat-surut>
- [32] OECD 2017 Case study: PetaBencana.id, Indonesia *Embracing Innovation in Government Global Trends* pp 23-26 [Online]. Available from: <https://www.oecd.org/gov/innovative-government/embracing-innovation-in-government.pdf>