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MAP FOR COMMUNICATING NATURAL HAZARDS: AN EVALUATION OF INDONESIA PRE-DISASTER SPATIAL INFORMATION

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Disaster prevention is essential to protect human lives and properties, especially in Indonesia whose nickname is supermarket for disaster. In the past few years, several disasters struck Indonesia and caused huge loss of life and great destruction. Inevitably, this situation needs proper response and anticipation to minimize the impact. As consequences, natural hazard should be assessed by planners and decision makers from the early stages. Therefore, the government or related institutions have the responsibility to provide, promote and disseminate information to public about natural disasters mitigation. The hazard information should be translated into maps and easily understood by planners, decision makers, public and other disaster management stakeholders. In other words, maps may function as effective tool for communicating natural hazards.

The objective of the paper is to evaluate published disaster maps in Indonesia, specifically pre-disaster or mitigation maps. Qualitative assessment by visual inspection was done to evaluate contents and cartographic aspects of the hazard maps. Maps evaluated are: Volcanic disaster map (BVMBG), Flood hazard map (National Agency for Disaster Management -BNPB), Landslide prediction map (Volcanology and Geological Hazard Mitigation Agency (BVMBG) -BMKG), Multi-hazard map (BAKOSURTANAL-ESDM-KEMPU-BMKG) and Flood prediction map (National Institute of Aeronautics and Space - LAPAN). The paper concludes some points to be noticed to establish pre-disaster maps, namely (1) effectively communicate natural hazard in Indonesia, (2) standardization of scale and vulnerability zone, (3) better map readability, and (4) synergy between institutions for comprehensive spatial and non-spatial analysis to achieve reliable hazard map.

KEYWORDS

Natural hazards, pre-disaster maps, mitigation

INTRODUCTION

Indonesia, which is geographically situated at the edge of four tectonic plates, is very prone to geologic disasters such as earthquakes, tsunami, landslides, and volcanic hazards. As noted by The Indonesian National Board for Disaster Management (BNPB), there were 667 disaster events in 2010 (BNPB, 2011). Act No. 24/2007 on Disaster Management is one of Indonesian government law to reduce the disaster risk. In this law, there is a regulation for regional authorities (province and regency/district) to arrange, establish and distribute Hazard Maps, which could be a preventive fundamental approach in disaster risk reduction program.

Nowadays, hazard mapping activities in their cycle have been conducted not only by central government, regional governments, university, but also by non-governmental organization. Besides being a good and effective medium to develop community disaster awareness, hazard maps also function for disaster management planning. For instance, they can provide budget estimation basis and its efficiency, give more integrative procedure for disaster response and systematic recovery, and trigger the cooperation among related institutions and stakeholders so they can be actively involved in disaster management activities. However, serious efforts from map producer and user are really necessary, so that hazard maps can be used in effective way to reduce disaster risks.

So far, Indonesian government still does not have disaster mapping methodology standards, for example, about a procedure to effectively communicate hazard areas into the maps. It is important since users/readers visual understanding normally come from the structure of maps. In other words, a good visualization will enhance the perception of the messages on the maps.

This paper aims to evaluate Indonesia hazard maps in disaster mitigation cycle.

TWO IMPORTANT ASPECTS TO BUILD EFFECTIVE HAZARD MAPS

The objective of hazard or pre-disaster maps is to provide community with the information on the range of possible damage. Therefore, clear and understandable information should be included. Two main aspects that should be considered in creating hazard maps are contents and cartography aspect.

Contents

To precisely inform about disaster, maps are needed in every disaster cycle. In mitigation cycle (pre-disaster), which contains preparation and prediction phase, maps should display physical or social information of the areas that are prone to disaster. Physical information could be base spatial data on detail topographic maps (administration boundary, transportation network, settlement area, land cover), public and social facilities related with disaster, and information about disaster prediction. Social information could be population maps or population density maps that support disaster mitigation, showing data about population to reduce the human death (Subagio and Amhar, 2009).

Udono and Sah (2002) mentioned that there are some basic information that must be displayed in hazard maps: base layers, disaster prediction containing past disaster records, information about evacuation route, and explanation about disaster phenomena behavior.

Besides that, intensity zone about disaster occurrence probability or disaster impact, which usually comes from accurate analysis, is also relevant to be depicted in hazard maps. It is in line with a research in San Francisco Bay US that showed that hazards maps that could show the likelihood of occurrence and intensity/severity would give most effective information (DSD, 1991).

According to Amhar and Darmawan (2007), there are some standards when creating disaster information system for cross-sectorial usage e.g., geometry, methodology, codification, and visualization standard. Geometry standard is related with map coordinates or reference system. Methodology standard will determine the fixed representation of information even though the maps analysis is conducted by different partly. Codification standard gives an easiness to process the elements, name the features (toponimy) or file. If the system has standard codes, visualization standard then easily achieved.

Cartography aspect

A good map should be understandable, well arranged, and equipped with clear and simple explanations. To gain good maps, cartography becomes an important aspect to be noticed.

Map design is essential since how the elements (title, legend, scale, north arrow, source) are placed and styled defines how usable a map is. Matina (2009) stated that there are three main cartography aspects that must be followed to create a good map: visual hierarchy, visual messages, and visual variables.

Visual hierarchy is about procedures to place and arrange labels around objects in a map, for example, about graphical setting of foreground (messages) and background or map context. By having good hierarchy, maps can show their message clearly. Any kind of visual variables, such as symbols that are made using color gradation yellow, red, purple, blue, green (color hue) or color lightness and color saturation when creating ordinal maps, will inform the message better to the map readers.

There is a standard template/layout issued by European RISKCATCH Project that formulates how to design hazard maps so that their message could be delivered properly (Figure 1). The map layout was obtained from a comprehensive eye-tracking test, which involved hazard specialist, common map users or random people, to 17 hazard maps. The test showed that contrast between informative elements and map background, symbology, the position and size of elements (e.g., legends, scale, title) gave an important visual impact to the map readers (Spachinger et al.,2008). It means, proper cartography layout can deliver information in a visually efficient manger and also can enhance maps ability to communicate their message.

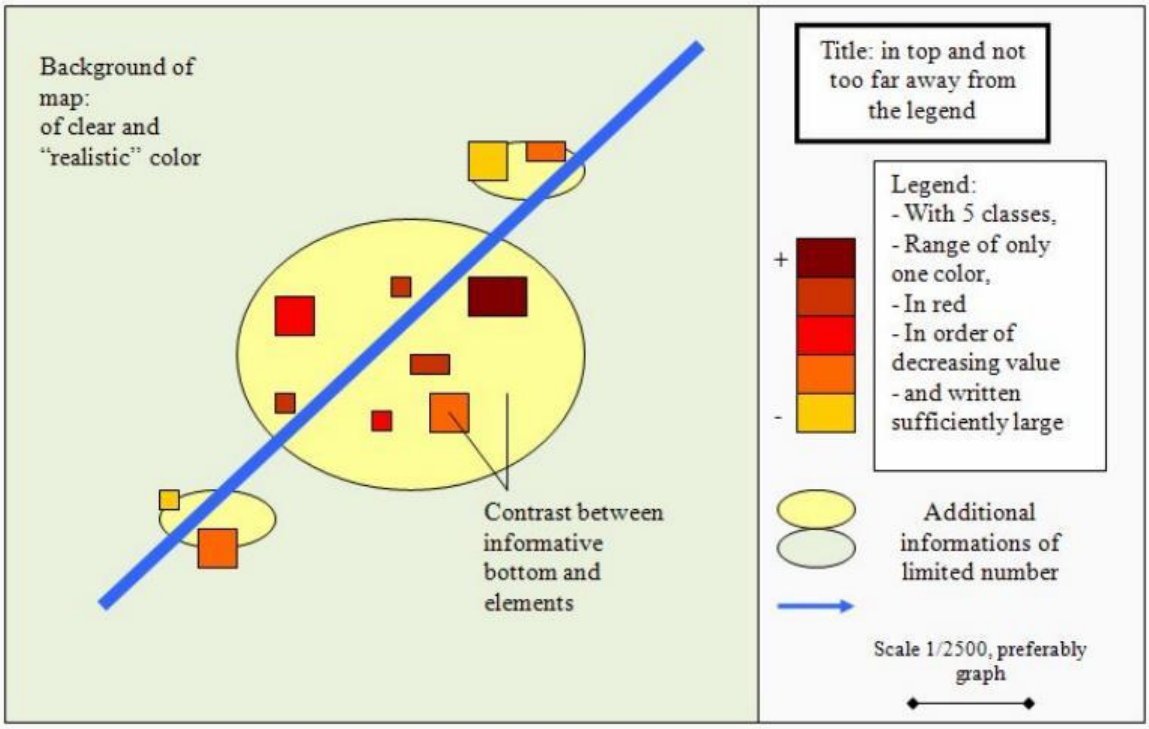

Figure 1. A risk map template suggestion proposed by the RISKCATCH project (Spachinger et al., 2008)

INDONESIAN PRE-DISASTER MAPS EVALUATION

Some government institutions have been produced and utilized mitigation (pre-disaster) or hazard maps i.e., Volcanology and Geological Hazard Mitigation Agency (BVMBG) - The Ministry of Energy and Mineral Resources of Republic Indonesia (ESDM), and Directorate of Water Resources - The Ministry of Public Works (KEMPU). The institutions produce mitigation maps at national and local scale. BVMBG concerns to map geological disasters such as tsunami hazard areas, subduction zone, active fault, earthquake area, volcanic hazard area, and mass movement; whereas KEMPU concerns to flood mapping.

At national scale, pre-disaster maps were created based on disaster event history, while at the local scale hazard predictive maps were created by employing GIS analysis (Subagio and Amhar, 2009). Besides those two institutions, there are local governments (responsible to provide Hazard Maps according to Disaster Management Act), universities, and NGOs that also produce hazard maps. Some government institutions such as National Coordinating Agency for Surveys and Mapping (BAKOSURTANAL), KEMPU, Meteorological Climatological and Geophysical Agency (BMKG), and ESDM collaborate to produce integrative maps. One of the results from this collaboration is a multi-hazard map for landslides and floods at national scale/coverage that having administration boundary up to regency level.

This paper evaluates some hazard maps as follow:

- Volcanic disaster map at local scale (BVMBG)
- Flood vulnerability area map at local and regional scale (National Agency for Disaster Management - BNPB)
- Landslide susceptibility map at provincial level (BVMBG-BMKG)
- Multi-hazard map at provincial level (BAKOSURTANAL-ESDM-KEMPU-BMKG)
- Flood prediction at national scale (National Institute of Aeronautics and Space -LAPAN)

Those maps were evaluated by comparing their content, cartography (presentation), and formal requirement for creating hazard maps. The evaluation was a qualitative assessment via visual inspection based on the criteria listed in Table 1.

Table 1. Evaluation criteria

No	Criteria	Detail of criteria
1	Geometry (coordinates, graticules)	
2	Overview map	
3	Scale	
4	Content	Location
		Occurrence
		Severity
		Base map
5	Readability	Title (topic, location, date)
		Font size and colour of text
		Labels (visual hierarchy)
		Colours (variable messages))
		Symbol (visual variable)
		Legend clarity
6	Source/processing info	Description of processing step/method
		Interpretation text/report
		Source maps
7	Additional Info	Relevant metadata
		Source
		Accuracy
8	Multilingual support	
9	Publication information:	Publisher
		Publication date
		Date of last update
		Author(s)

At national scale, landslide susceptibility maps, volcanic hazard maps and flood vulnerable area maps have been available. These maps are created based on historical evidence of the events in the corresponding area. Figure 2 shows landslide vulnerable area map created by Directorate of Environmental Geology (DGTL). This map shows four susceptibility zones for the entire area; and along west coast Sumatra Island and Papua Island, the susceptibility is high.

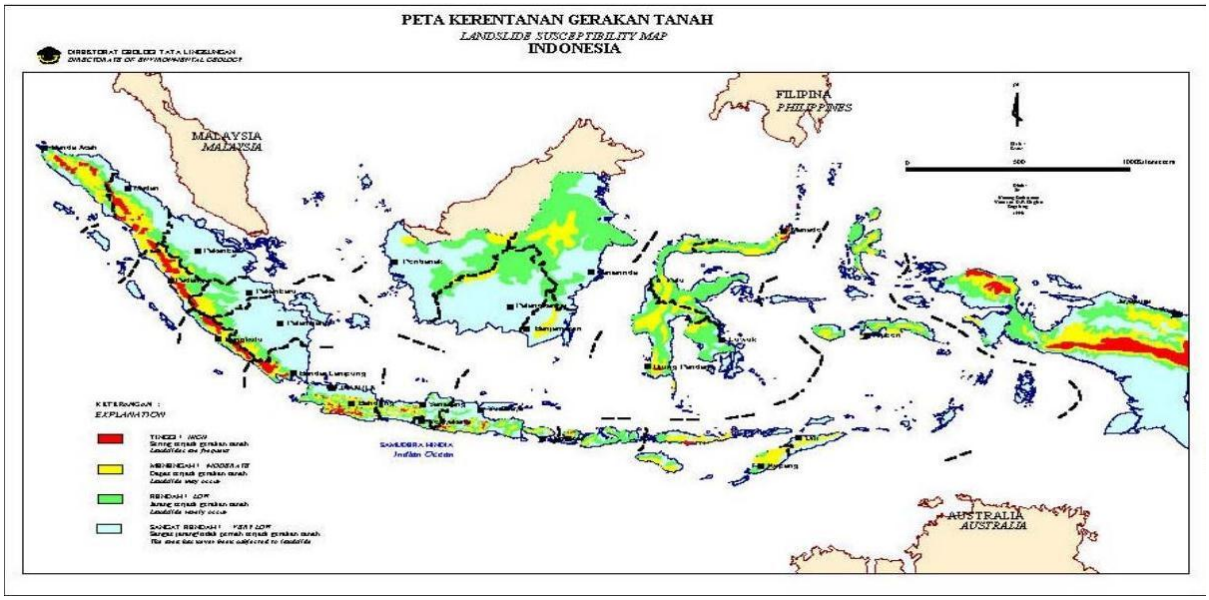

Figure 2. Landslides susceptibility map (DGTL)

A bigger-scale landslides susceptibility map was also produced by BMKG-PVMBG, at provincial level (Figure 3). However, its detail level of information is the same with the map at national level. This condition is not optimal, because for practical purposes e.g., quick response just after disaster, more detail information about land use, contour line, river, topographic surface is preferable. Regarding its content (severity), the map provides slightly different information. In this map, almost all parts are dominated by low susceptibility zone without clear indication about the other three zones. It also has different legend and symbol (color). This findings show about ununiformed method and standard for those two maps.

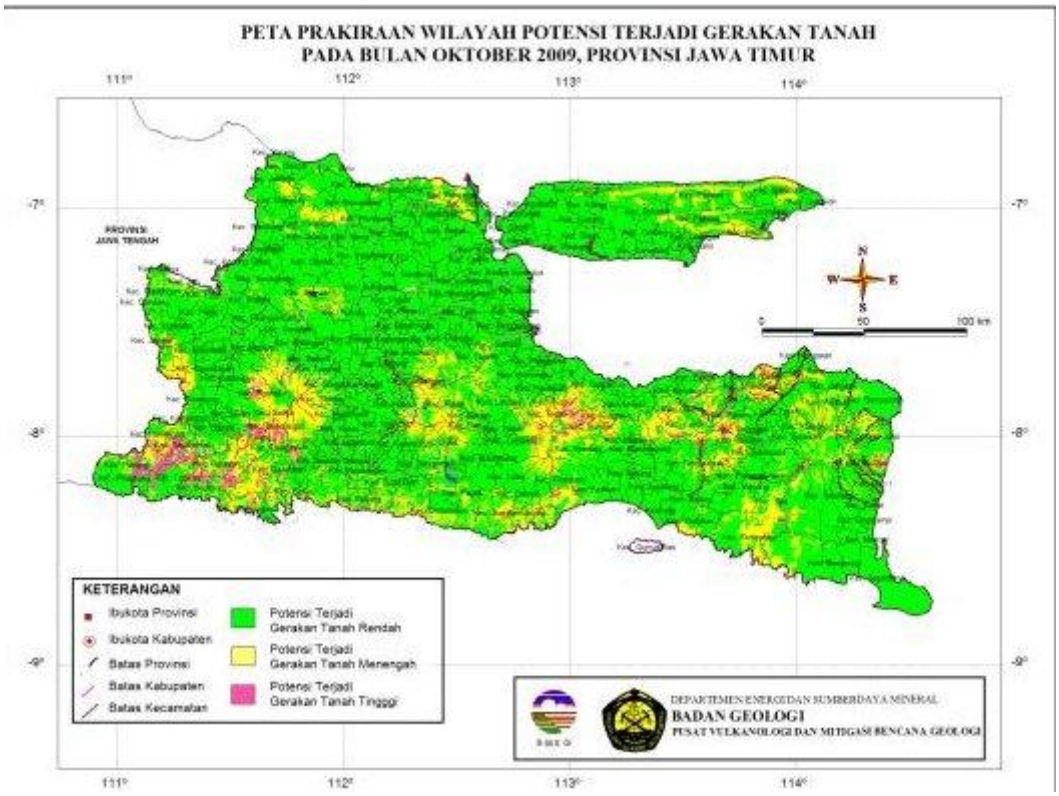

Figure 3. Landslides prediction map (BMKG-PVMBG)

Figure 4 till 6, display the same situation that is also apparent when we analyzing a flood prediction map from LAPAN (at national level), BAKOSURTANAL-BMKG-KEMPU-ESDM (at provincial level), and BNPB (at district level). The provided information on the bigger scale maps are not more detail than information from the smaller scale maps.

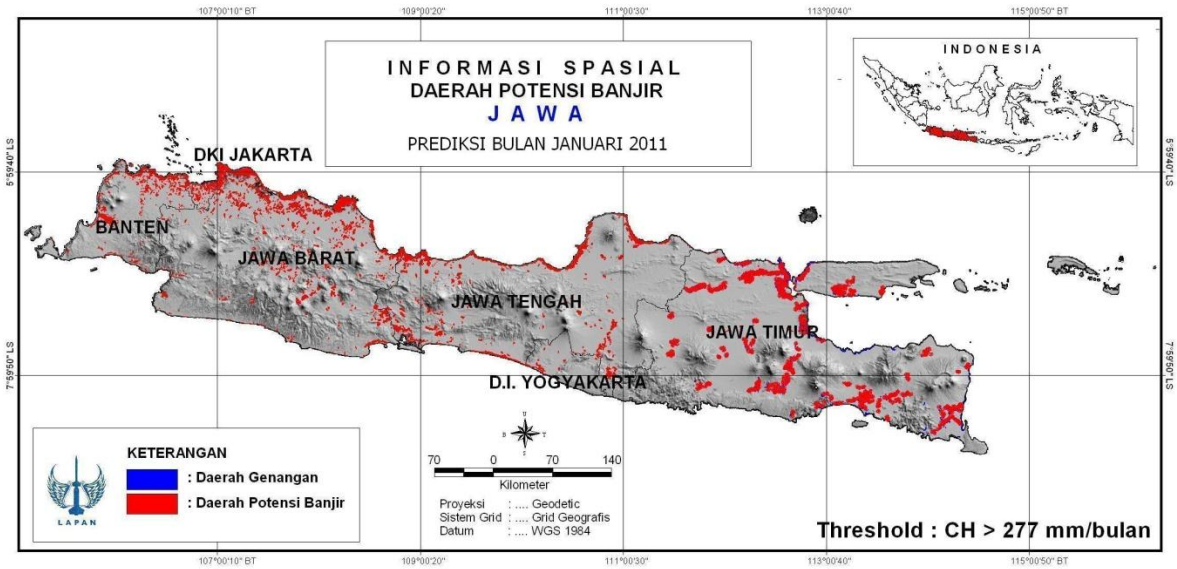

Figure 4. Floods prediction map (LAPAN)

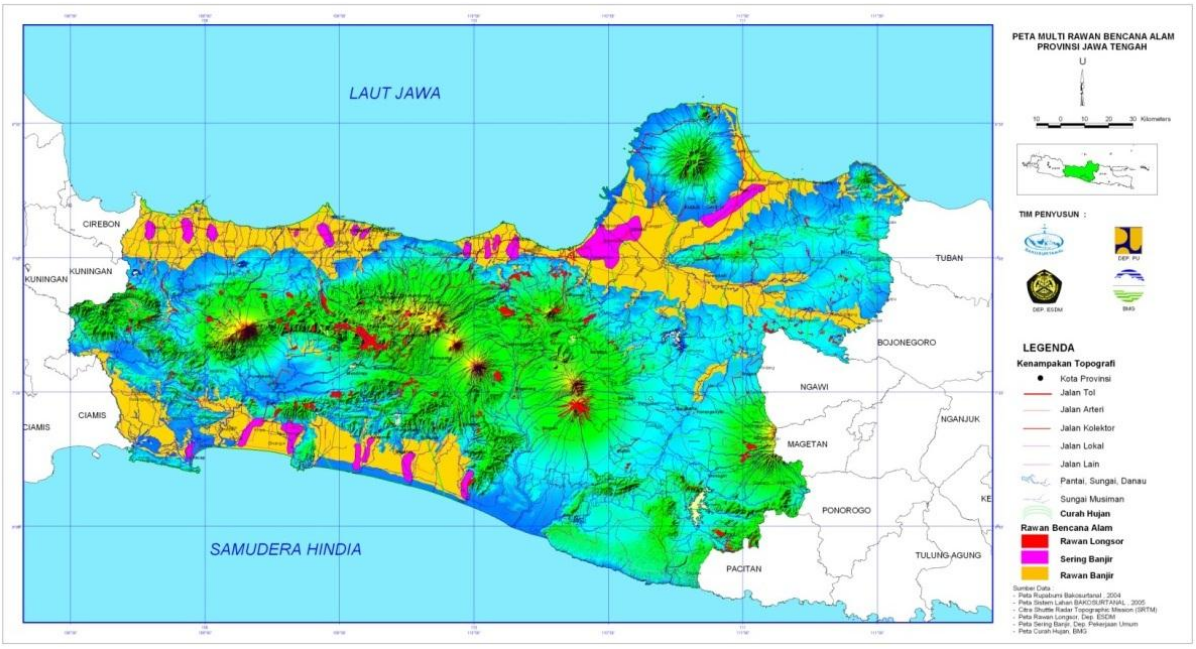

Figure 5. Multi-hazard map, covering landslides and flood hazard (BAKOSURTANAL-KEMPU-ESDM-BMKG)

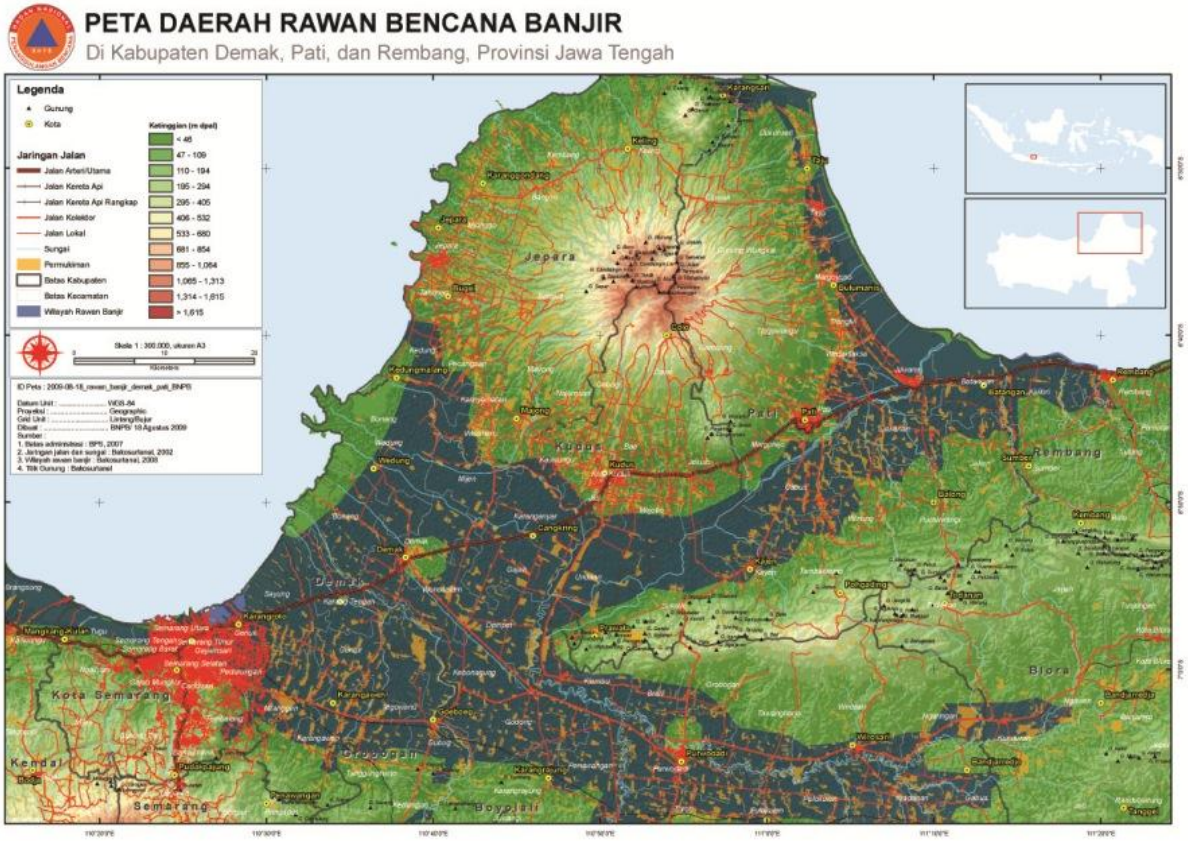

Figure 6. Flood hazard map covering several regency (BNPB)

Those three maps just give information about flood area location without severity level. Actually, for practical mapping, they should give information about tidal or inundation, at least in contour accuracy 50cm (Amhar and Darmawan, 2007). Those information are important for disaster responses such as for evacuation route establishment, embankment setting and etc. Only for the national level map, there is flooded area information, but just at very small scale and with improper accuracy. The maps should also display information about history of flooding in the area.

Map scale is really significant because it determines a detail level of information. Hence, standardization should be established so that every map can focus on definite information and users. As illustration, for users who work as regional planners, they need maps that fit and useful for development planning, somaps at scale 1:50.000 – 1:100.000, which display disaster types with a 1: 25.000 topographic map as background are adequate for them. However, for people who deal with emergency response, they cannot work just by relying on those medium scale maps. They need bigger scale maps and more detail information.

Standard methods to determine vulnerable areas also need to be established. Actually, there are some methods that had already been formulated for each disaster type in a workshop about multi-hazard mapping in 2006 (Darmawan and Theml, 2008). For example, Indonesian National Standard (NSI), Transient Rainfall Infiltration and Grid-Based Regional Slope Stability Model (TRIGRS) for landslides mapping; Buffering (5 km), HVC (hazard, Vulnerability, Capacity) method for volcanic hazard mapping. The government just needs to formalize which methods that will be used as standard methods.

Cartographically, those pre-disaster maps have similar pattern. Map elements are just positioned into empty spaces. Map readability aspects are not really highlighted. Some labels are too big or too small (i.e., not proportional). Their labels also cross each other and do not have contrast with the map background. Symbols size and legend are not proportional. Another thing, no maps provide information about the methods (i.e., how the maps were created) and information about publication (serial and time of publication). Those maps just display their sources.

Volcanic hazard map (Figure 7), is presented and visualized better. This map depicts complete information in detail about vulnerable area, evacuation route and shelters for displaced-affected people. Almost all requirements for a good map are fulfilled. The map also presents text information bilingually, English and Indonesian. It will give good-effect because its readers range will be large, not only local authorities or local users but also international communities. Unfortunately, it has excessive text information that distracts the entire appearance.

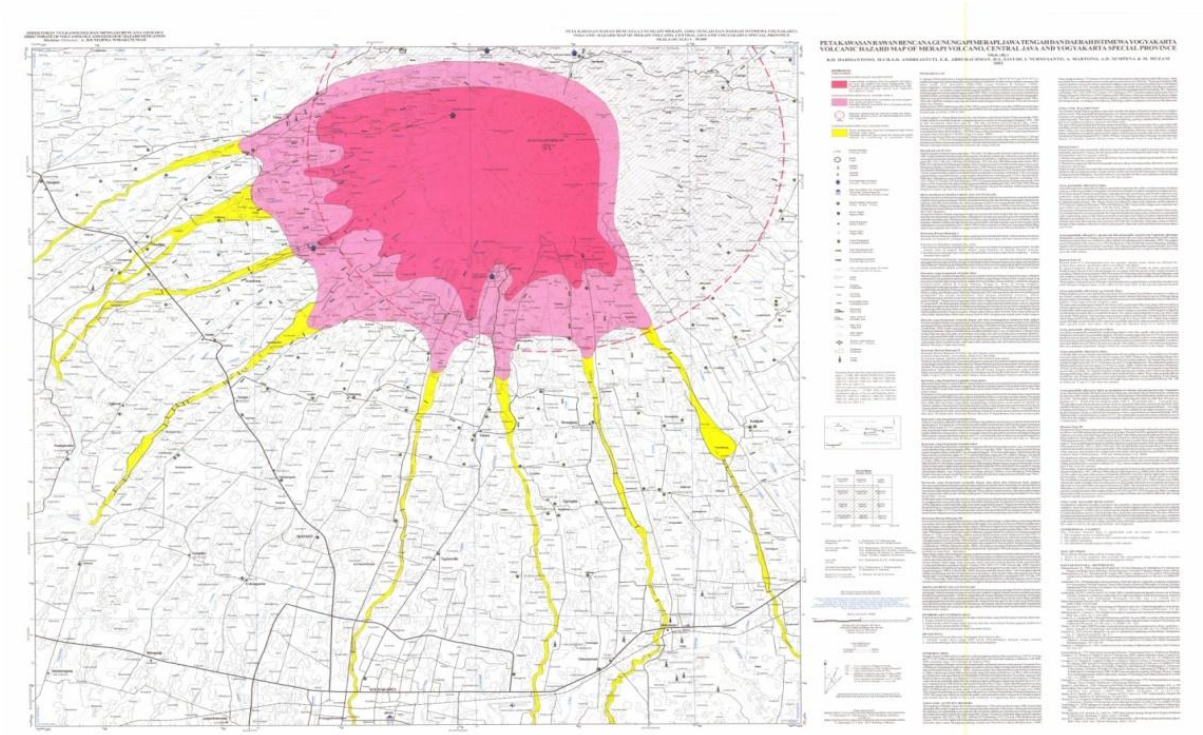

Figure 7. Volcanic hazard map of Mt. Merapi, Central Java (PVMBG)

Completely, evaluation result is displayed in table 2 as follow:

Table 2. Evaluation on published hazard maps in Indonesia

Criteria	DGTL (Figure 2)	BMKG-PVMBG (Figure 3)	LAPAN (Figure 4)	BAKOS (Figure 5)	BNPB (Figure 6)	PVMBG (Figure 7)
Geometry (coordinate/graticule)	No	Geographic	Geographic	Geographic	Geographic	UTM and geographic
Overview map	No	No	Yes	Yes, need more names	No names/location	Clear
Scale	Bar and numeric	Scale bar	Bar	Bar	Bar and numeric	Clear
Content:						
- Location/AOI	Approximate/No coordinate	Clear	Yes	Yes	Clear	OK
- Occurrence	Landslides	Landslides	Flood potential	History of flood, flood hazard n landslide hazard	Flood hazard	OK
- Severity	Four zones of landslidessusceptibility	Covers threezones of susceptibility	No	No	Only occurrence, No zones	OK
- Base map	Only provincial boundary	Only administration boundary	Only DEM and province boundary	Roads, hydrology, administration	Roads too crowd and too detail	OK
Readability:						
- Title (topic, location, date)	Clear, No date	Clear	Clear	Clear, No date	Clear, No date	OK
- Font size and color of text		Contrast	Province labels too big	Small font size	Contrast but not clear/blurry	Too many text/explanation
- Labels (visual hierarchy)	No province name, more labels (ocean, island)	No label for ocean, to small	Doesn't show the location of potential area, only provinces	No labels for mountain or regency with hazard	Small label for mountain, too detail	
- Colors (variable messages)	OK	No background	Inundation cannot be seen, small scale		Incongruent	Contrast
- Symbol (visual variable)	No legend for capital symbol, admin boundary	OK	Contrast	Wider line symbol with contrast color		Need more colors to differentiate line symbols
- legend clarity	Not all symbols clarified	Clear	Clear but not complete	Clear but not complete	Small legend	Clear
Source/processing info:						
- Description of processing step (method)	No	No	No	No	No	Yes
- Interpretation text/report	No	No	No	No	No	Yes
-Source maps	No	No	No	Yes	Yes	Yes
-Producer	No	No	No	Yes	Yes	Yes
Additional Info:			No			
- Relevant metadata	No	No	Threshold		Map ID	Too much text
- Accuracy	No	No	No	No	No	No
Multilingual support	Yes	No	No	No		Yes
Publication information:						
-publisher	Yes	Yes	Yes	Yes	Yes	Yes
-publication date	No	No	No	No	No	Yes
-date of last update	No	Yes	No	No	No	Yes
-author(s)	No		No	No	No	Yes
-copyright	No	No	No	No	No	

CONCLUSION

Pre-disaster maps could inform public about natural hazards, strengthen people's risk awareness, and then reduce disaster risks. However, those maps should be the standardized and accurate hazard maps so that they can achieve their goal: informing and warning people about hazards and disasters. Pre-disaster maps equipped with evacuation route, shelters information for refugees, and other practical information could contribute to disaster response.

Based on some previous analyses, this paper concludes some points that must be noticed to establish good and effective pre-disaster maps.

1. It is important to have standardization for scale and vulnerability zones so every hazard maps in any specific scale will have distinct readers and provided information.

2. Related with map readability such as maps elements (texts, labels, legends) size and positioning, symbolization, should consider contrast between background and the elements. The maps elements are not just complements, but become an important mechanism in giving visual impact to map readers while communicating maps.

3. Reliable hazard prediction maps should be generalized from comprehensive spatial and non-spatial analyses, not just from historical recorded events.

4. Therefore, the process demands synergetic actions from all related or responsible institutions in order to produce hazard maps that are highly-interoperability oriented, standardized and updatable. Hopefully too, using the same standards, provincial and district authorities could provide reliable hazard maps as mandated by Indonesian Disaster Management Law.

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