DMUCH Institute of Disaster Mitigation for Urban Cultural Heritage, Ritsumeikan University

Assessing Effectiveness and Adoption of Maps for Risk Communication and Disaster Learning in Indonesia

By: Kartika Puspita Sari

20 June 2020

Dissertation Outline

Introduction

Chapters:

1. Accessibility and suitability of maps for risk communication in Indonesia
2. Learning from Magelang Regency: Understanding effectiveness and adoption of an interactive map application for risk communication
3. Compared to static maps, are interactive maps are more preferred and useful to learn disasters? Understanding high school students' perceptions of map usage in disaster learning

Conclusions and recommendation

Introduction

Background

- Understanding Risks of Disasters - One of four priorities in Disaster Risk Reduction (the Sendai Framework for Disaster Risk Reduction 2015-2030).
- Maps can facilitate risk understanding due to their ability to visualize the spatio-temporal components of hazards and disasters (Dransch et al., 2010) —> **Maps for use as a visual risk communication tool** (Charrière et al. (2012) and **a spatial decision-support tool** (Thomas, 2018).
- Maps used for risk communication generally seek to raise **public awareness** and **understanding of disasters** or threatening **hazards** in a spatial context. As individuals' awareness on disasters increased, it is expected that attitudes towards protective actions (perceptions on the importance of being prepared (preparedness) and seeking more information about disasters) will also eventually be improved.
- As risk communication intends to **enhance risk reduction**, maps for example should be able to help people understand the spatial context of **the evacuation plan** for the emergency situation.
- Rapidly evolving technologies now provide a platform to disseminate disaster information more widely. However, this situation somehow also leads to the generation of vast amounts of unusable data or applications that are not adopted, used, or applied. The number of Internet sites distributing spatial information about disasters are **so numerous, disparate, and disconnected**. They likely do not adequately reach the necessary audiences and can be confusing.

Research problems

- Little is known about the way maps are adopted and disseminated as a source of disaster information.
- Limited research explores how maps directly affect decision-making or how people process and utilize geographic information for risk reduction actions.

Table 1 Research Objectives, Questions, Hypotheses, and Methodology

Research Objectives		Research Questions		Research Hypotheses/ Propositions	Methodology
RO1	To examine dissemination of maps about disasters for the public in Indonesia.	RQ1.1	How have maps about disasters been publicly available in Indonesia?	Considering the limited availability of resources and technology in Indonesia, there is a limited number of publicly accessible disaster maps in this country.	• Online census and content analysis. • Classifying maps that publicly available by types of maps and by contents
		RQ1.2	How suitable are publicly available Indonesian local disaster maps for communicating risks to the public?	There are small numbers of publicly accessible disaster maps suitable for risk communication purposes in this country.	• Conducting a content analysis by evaluating the accessible maps using a set of modified effective map criteria, which was initially developed by Henstra et al. (2019)
RO2	To assess the effectiveness of maps for risk communication.	RQ2.1	How effective can maps be used for communicating threatening hazards and an evacuation plan for a community at high risks?	To some extent, maps can be effective for communicating threatening hazards and an evacuation plan for a community at high risks.	• Experimental study: map trials with pre- and post-measurement. • Adapting map usability evaluation from prior research to measure map effectiveness.
		RQ2.2	Can maps influence risk perception and motivate users to do protective actions?	Maps can influence risk perception and motivate users to do protective actions.	• Experimental study: map trials with pre- and post-measurement. • Comparing users' risk perception and protective behavior before and after map reading.
		RQ2.3	Are interactive disaster maps more efficient, effective, and satisfying than the conventional static maps for learning disasters?	Compared to the static maps, interactive disaster maps are more efficient, effective, and satisfying.	• Experimental study: map trials with pre- and post-measurement. • Comparing the map usability of both interactive and static maps by performing evaluation using modified map usability criteria from prior research.
RO3	To understand the adoption of (interactive) maps as a source of disaster information from different types of users.	RQ3.1	How willing are different kinds of users to use interactive disaster maps as a source of information?	Since interactive maps are easy to use, targeted different users are willing to use the maps, with some conditions.	• Using technology management and acceptance model approaches to understand the adoption of interactive maps (maps as an information system, an e-government service). • An extended Information System Success Model (DeLone & McLean (1992), (2003)).
		RQ3.2	What factors influence the intention to use the maps?	External facilitating resources and individual's self-efficacy, information quality (perceived usefulness), system quality (ease of use), satisfaction, and net benefits affect users' intention to use.	

Summary of Chapter 1

Accessibility and suitability of maps for risk communication in Indonesia

Research Question 1.1

How have maps about disasters been publicly available in Indonesia?

Table 1 Numbers of municipalities with publicly available disaster maps relevant to the numbers of municipalities exposed to specific hazards

Kinds of Natural Hazards	Number of municipalities at risk of this hazard*	Number of municipalities providing maps about this hazard	Percentage
Floods	480	57	11.88%
Landslides	360	47	13.06%
Extreme Weather	423	30	7.09%
Earthquakes	190	27	14.21%
Drought	293	26	8.87%
Environmental Fire	190	26	13.68%
Volcanic Eruption	54	18	33.33%
Abrasion / Tidal Wave	150	16	10.67%
Tsunami	50	18	36.00%

** Based on disaster records in the last 20 years (1999-2019) from DIBI BNPB*

- There are only 410 maps about disasters publicly available after scanning 1,180 government websites, geo-portals, and web maps of 514 municipalities in Indonesia.
- Most of the maps are displayed on the disaster management agency websites. There is no central repository for disaster maps
- Map redundancy.

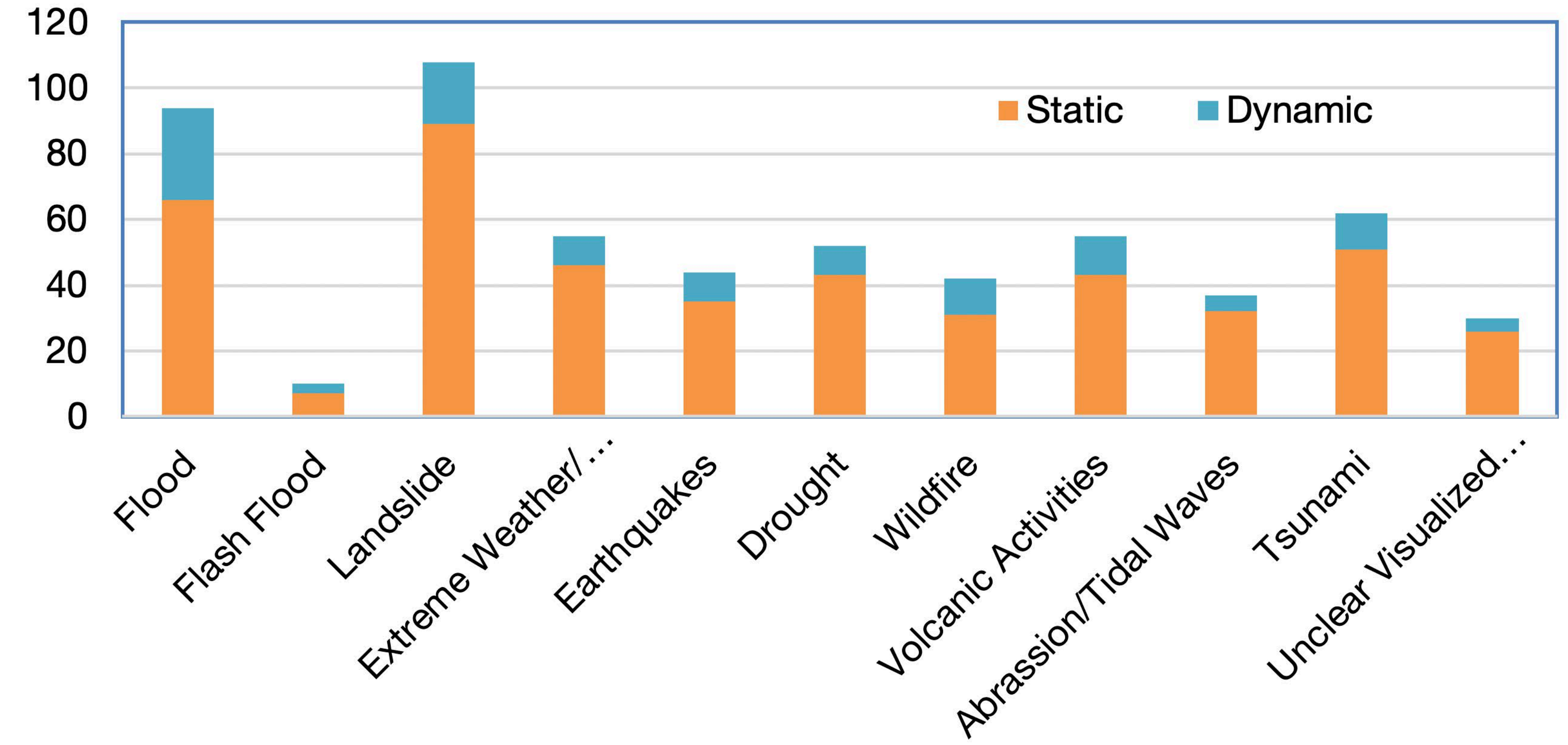


Figure 1 Quantitative overview on natural hazard processes and their representation in static maps and dynamic/interactive maps

Research Question 1.2

How suitable are publicly available Indonesian local disaster maps for communicating risks to the public?

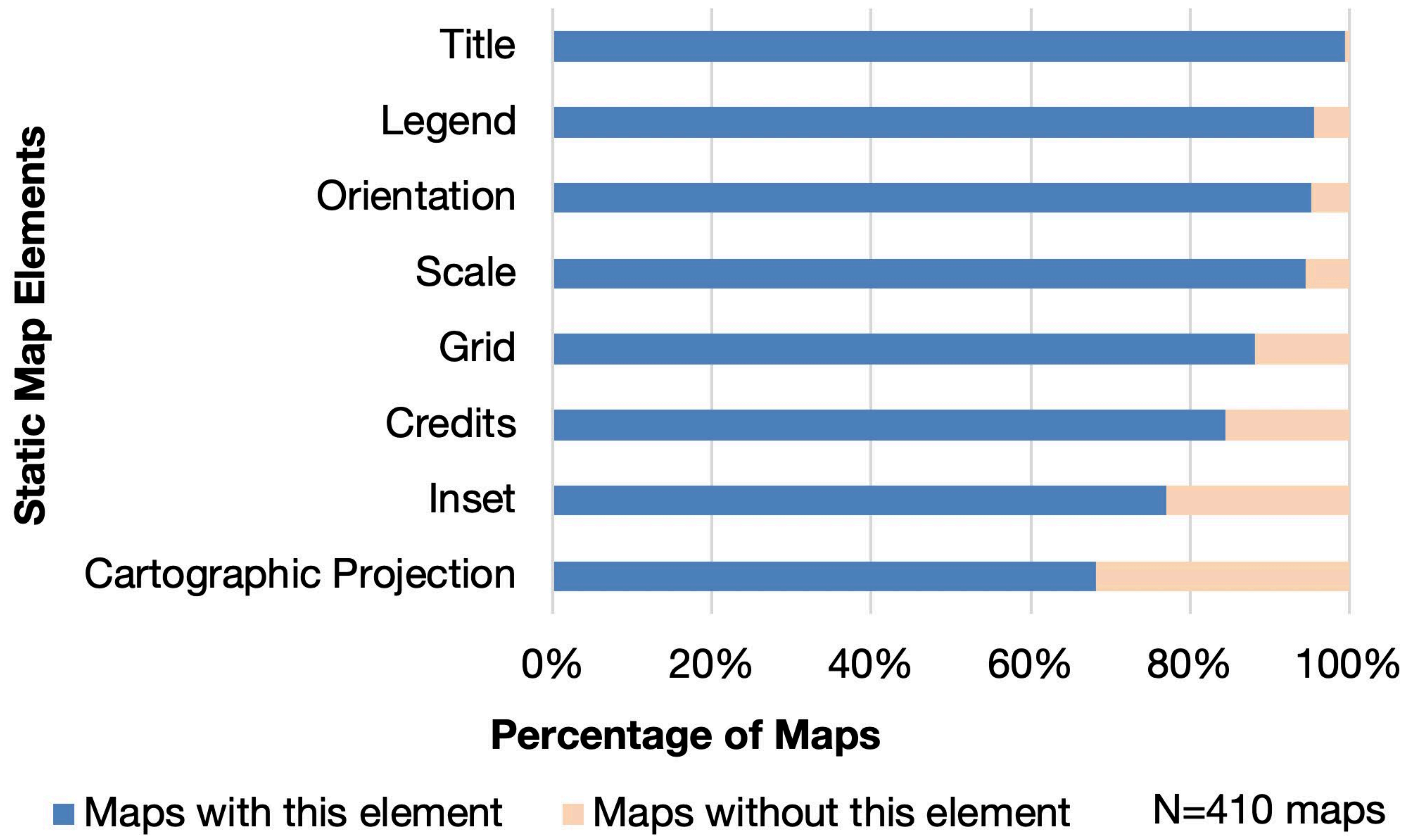


Figure 2 Completeness of map elements of the publicly available static disaster maps

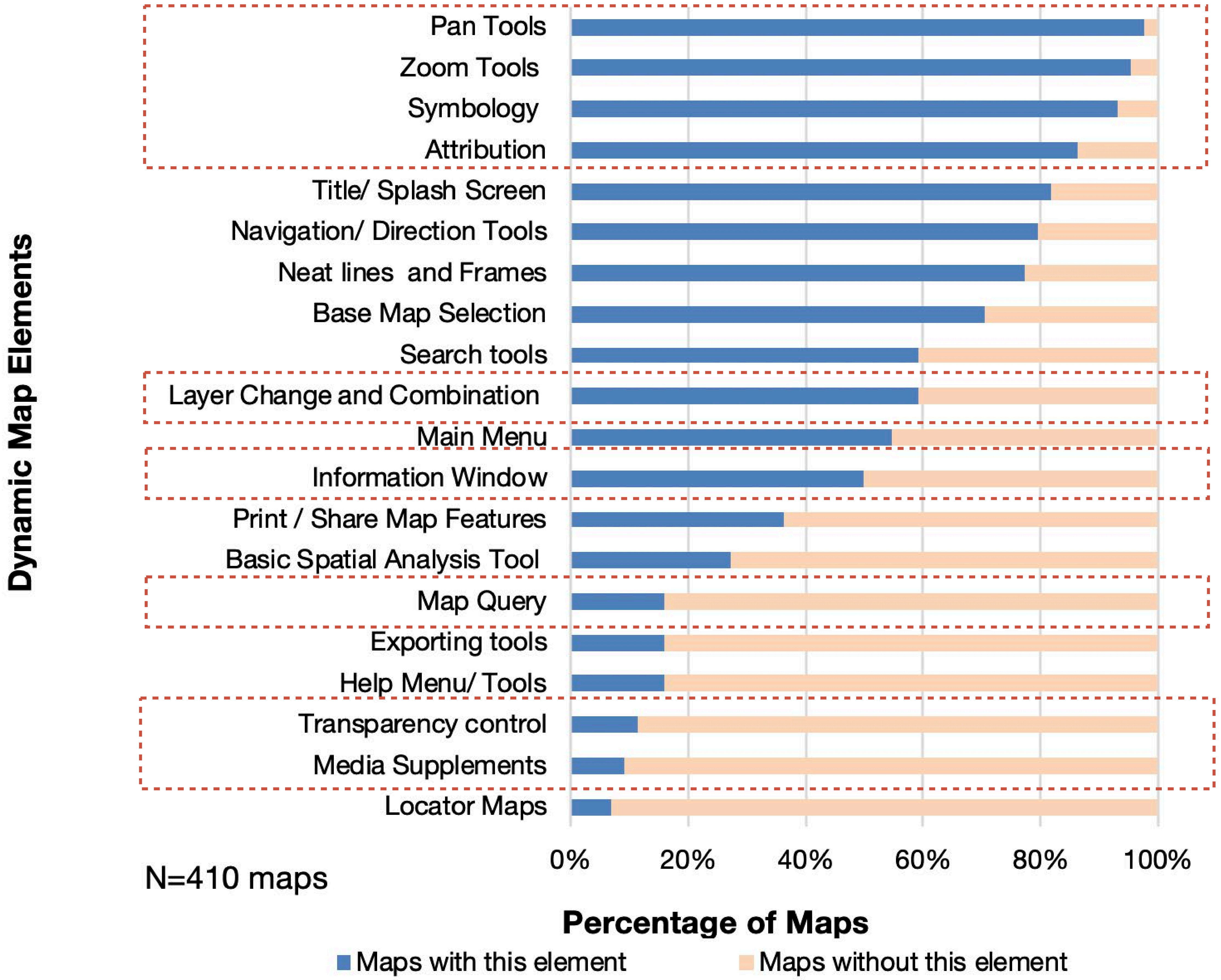


Figure 3 Completeness of map elements of the dynamic disaster maps available to public

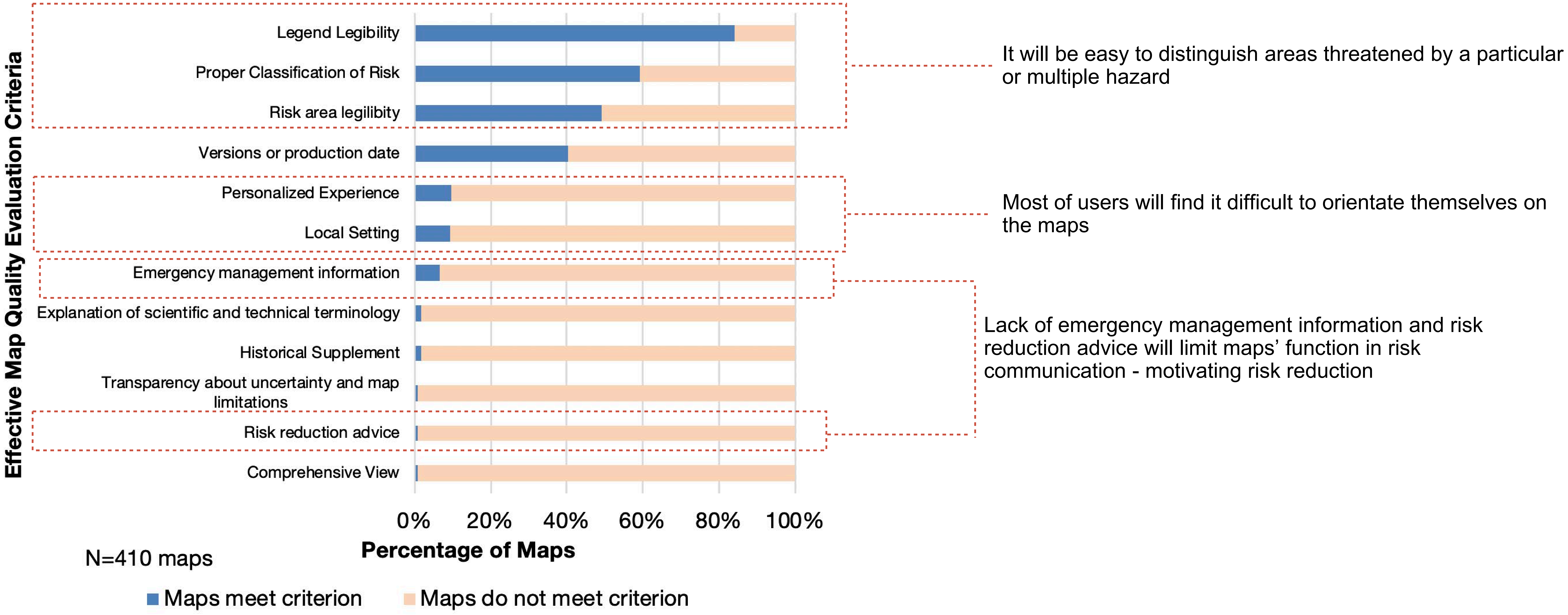
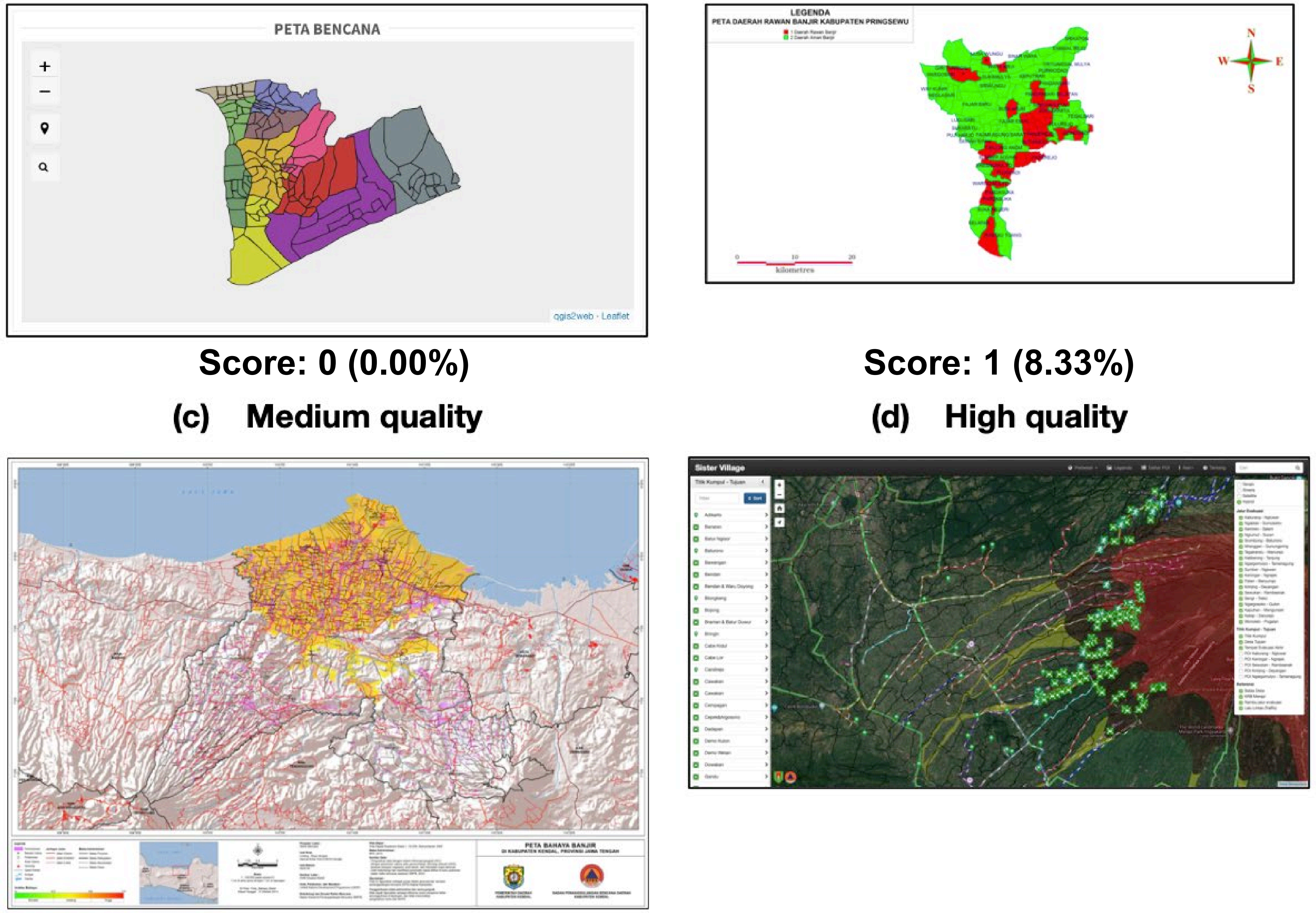


Figure 4 Characteristics of disaster maps available to public

(a) Unidentified cartographic object

(b) Low quality



Score: 0 (0.00%)

Score: 1 (8.33%)

(c) Medium quality

(d) High quality

Score: 4 (33.67%)

Score: 8 (66.67%)

Figure 5 Comparison of maps about disasters and associated quality scores

(a) A disaster map displayed on the website of BPBD of Tanah Laut Regency, South Kalimantan Province, score 0% (zero out of twelve).

(b) A flood hazard map displayed on the website of BPBD Pringsewu Regency, Lampung Province, score 8.33% (one out of twelve).

(c) A flood hazard map provided by Kendal Regency, Central Jawa Province, score 33.33%.

(d) A volcano evacuation map displayed on a disaster information system called SIKK Magelang *(stands for Sistem Informasi Kebencanaan Kabupaten* Magelang) created by BPBD Magelang Regency, Central Jawa Province, score 66.77%.

Summary of Chapter 2

Learning from Magelang Regency: Understanding effectiveness and adoption of an interactive map application for risk communication

Research Question 2.1

How effective can maps be used for communicating threatening hazards and an evacuation plan for a community at high risks?

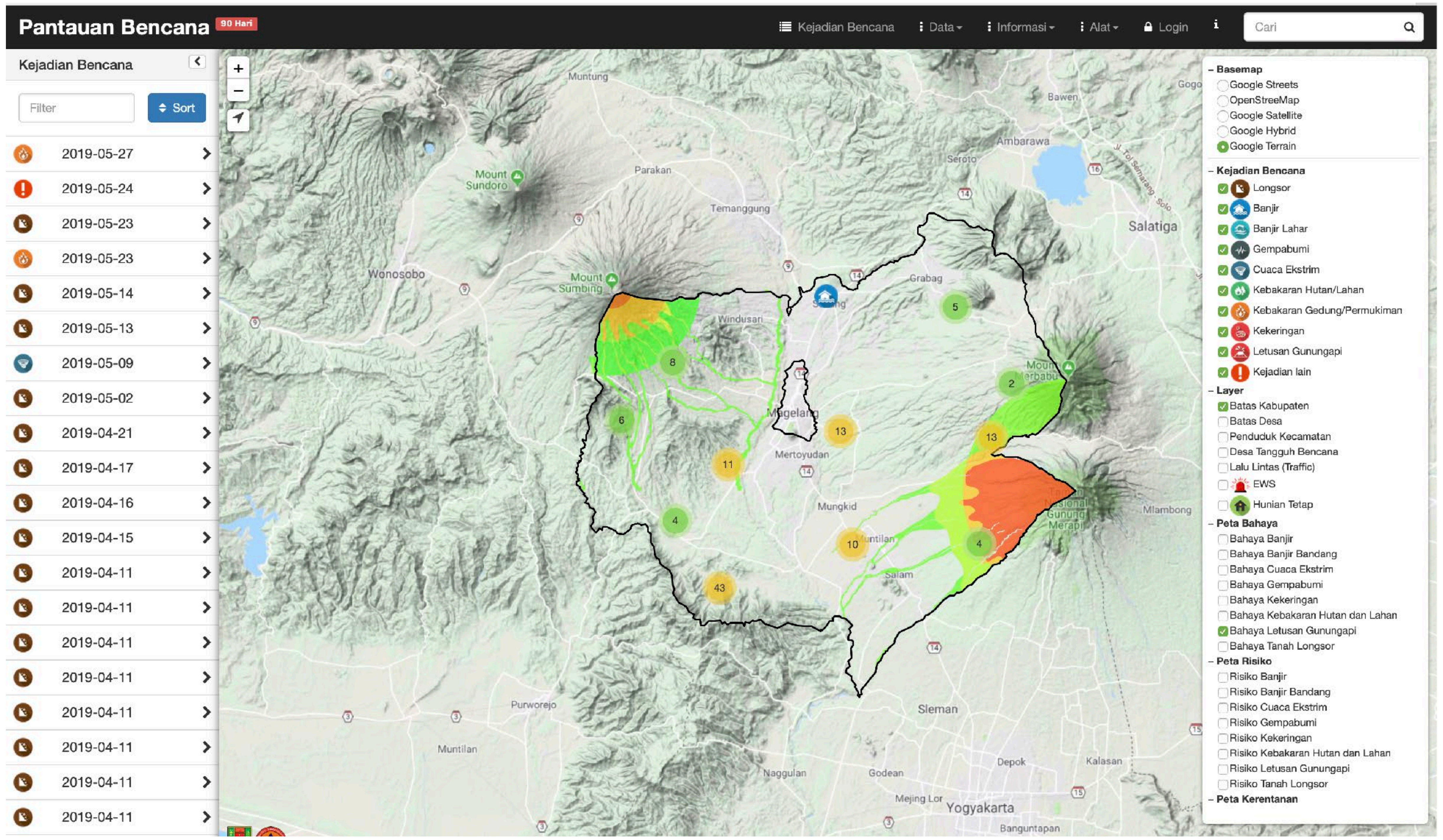


Figure 6   SIKK Magelang - Desktop Web Platform

By using SIKK Magelang (a local government developed a GIS-based e-government disaster application in Indonesia) and respondents who live in Sumber Village (a village located closely to Merapi volcano in Indonesia), this study tried to measure the effectiveness of maps for communicating threatening hazards and evacuation plans to the high-risk community as the primarily targeted users.

- SIKK Magelang significantly can change individual perceptions on hazard knowledge and risk perception.
- SIKK Magelang can increase understanding about the most frequent disasters. However, the maps are more likely to decrease understanding about the evacuation sites.
- Participants' are more likely to shift their perceptions on the risks of hazards to be more similar to hazards visualized on the maps after viewing the maps, for the case of flash flooding and wildfire maps.

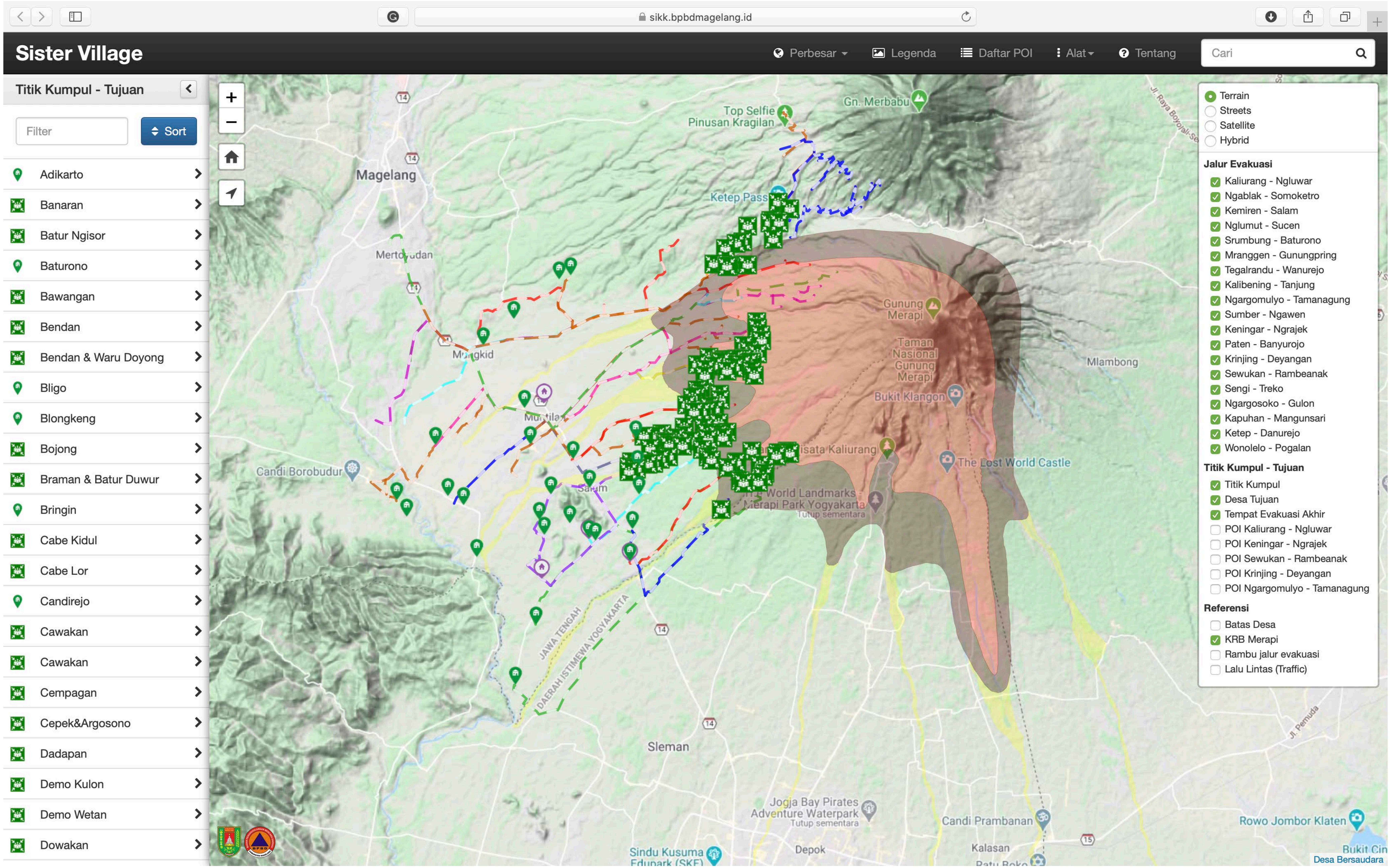


Figure 7 Sister Village – Paired villages evacuation plan for Merapi Volcano's emergency

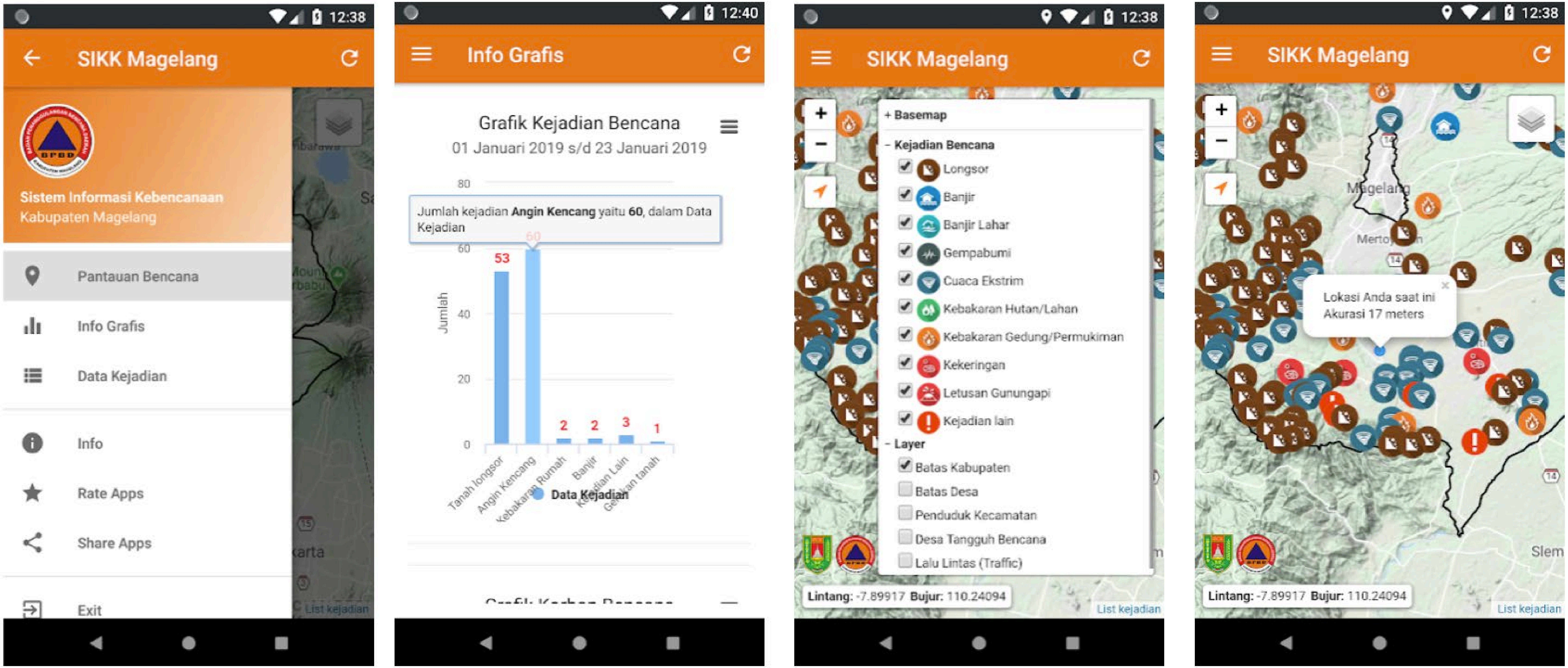


Figure 8 The Mobile Application Interfaces of SIKK Magelang (Android)

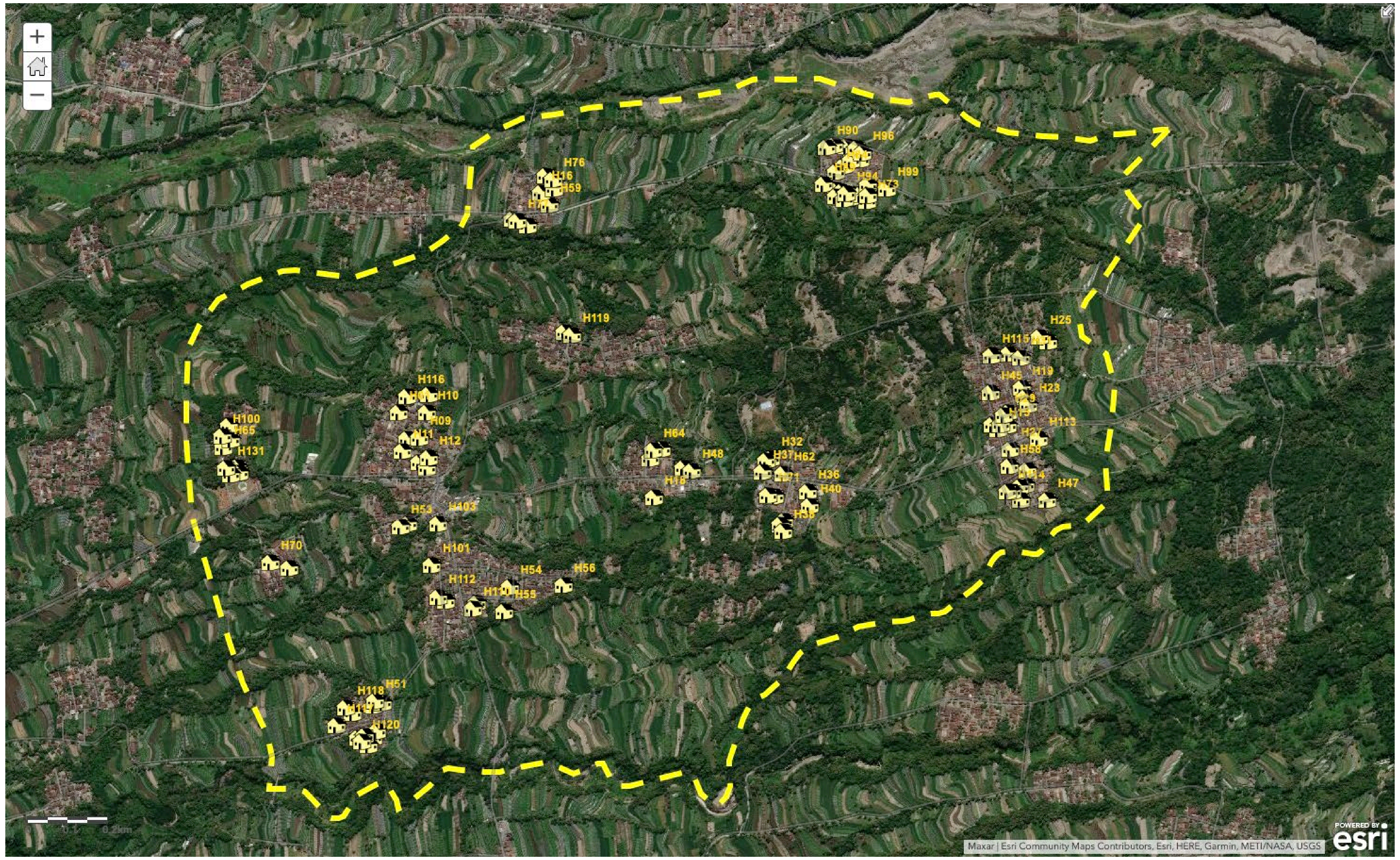


Figure 9 Locations of the Respondents' house in Sumber Village

Source: Field Survey December 2019 - January 2020

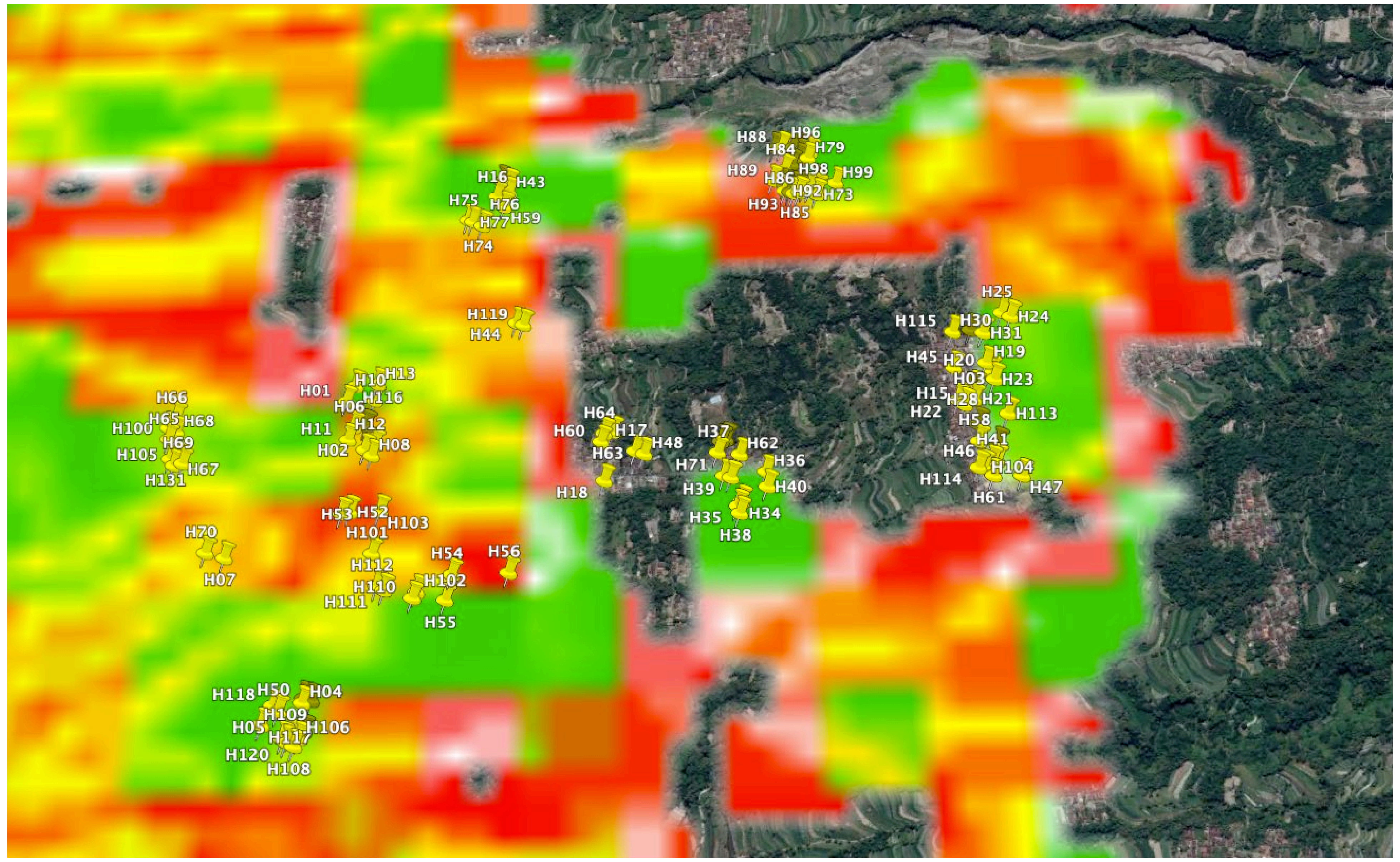


Figure 10 Locations of Respondents' house compared to Flood Prone Areas

Based on the hazard visualizations on the maps:

- 91 (75.2%) respondents houses are exposed to flood hazards;
- 12 (9.9%) respondents houses are exposed to flash flood hazards;
- All respondents (121, 100.0%) houses are exposed to extreme weather, droughts, earthquakes, and volcanic eruptions;
- All respondents (121, 100.0%) houses have no risk of landslides and wildfires.

• Perceptions on the Evacuation Sites for Future Eruptions

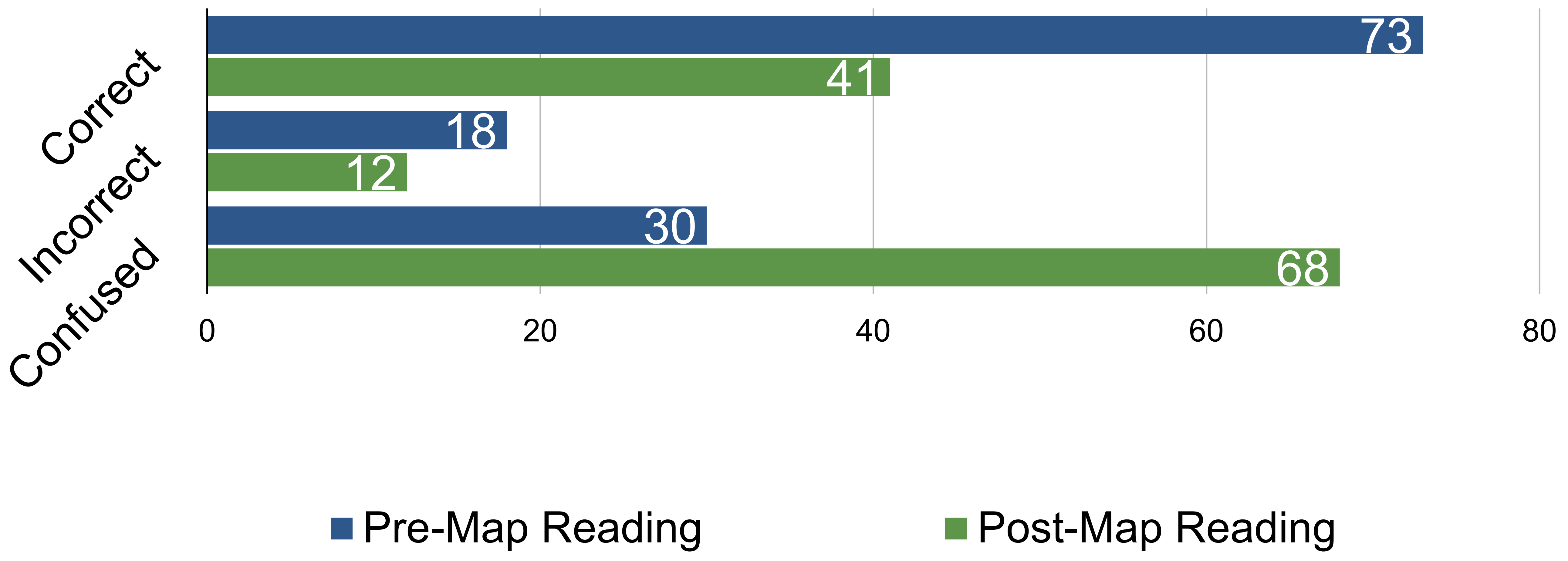
How to measure?

The right answer: **Pucungrejo**

Before: Pucungrejo (Correct), Ngawen or other Villages (Incorrect), Pucungrejo and Ngawen or did not answer (Confused)

After: Pucungrejo (Correct), Ngawen or other Villages (Incorrect), Pucungrejo and Ngawen or did not answer (Confused)

Figure 11 Correctness on the Evacuation Site Information



From Figure 11 we can see that fewer participants correctly answered the questions on the evacuation site for the future eruption after reading the map, and more people got confused on the evacuation site after reading the map.

The McNemar-Bowker test revealed that the changes in perception on the location of evacuation sites before and after the map reading, were not symmetrical χ^2 (3, N=121) = 33.73, p = 0.000.

Table 2 Frequency on the shifts of answers

Before	After	#	%	Code
Correct	Correct	37	30.58%	1
Correct	Incorrect	6	4.96%	2
Correct	Confused	30	24.79%	3
Incorrect	Correct	1	0.83%	4
Incorrect	Incorrect	4	3.31%	5
Incorrect	Confused	13	10.74%	6
Confused	Correct	3	2.48%	7
Confused	Incorrect	2	1.65%	8
Confused	Confused	25	20.66%	9
		121	100.00%	

• Perceptions on the Most Frequent Disasters

How to measure?
The answer based on SIKK Magelang: Extreme Weather/Storms
Before: Extreme Weather/Storms (Similar), Volcanic Eruptions (Different), did not answer (Confused)
After: Extreme Weather/Storms (Similar), Volcanic Eruptions (Different), did not answer (Confused)

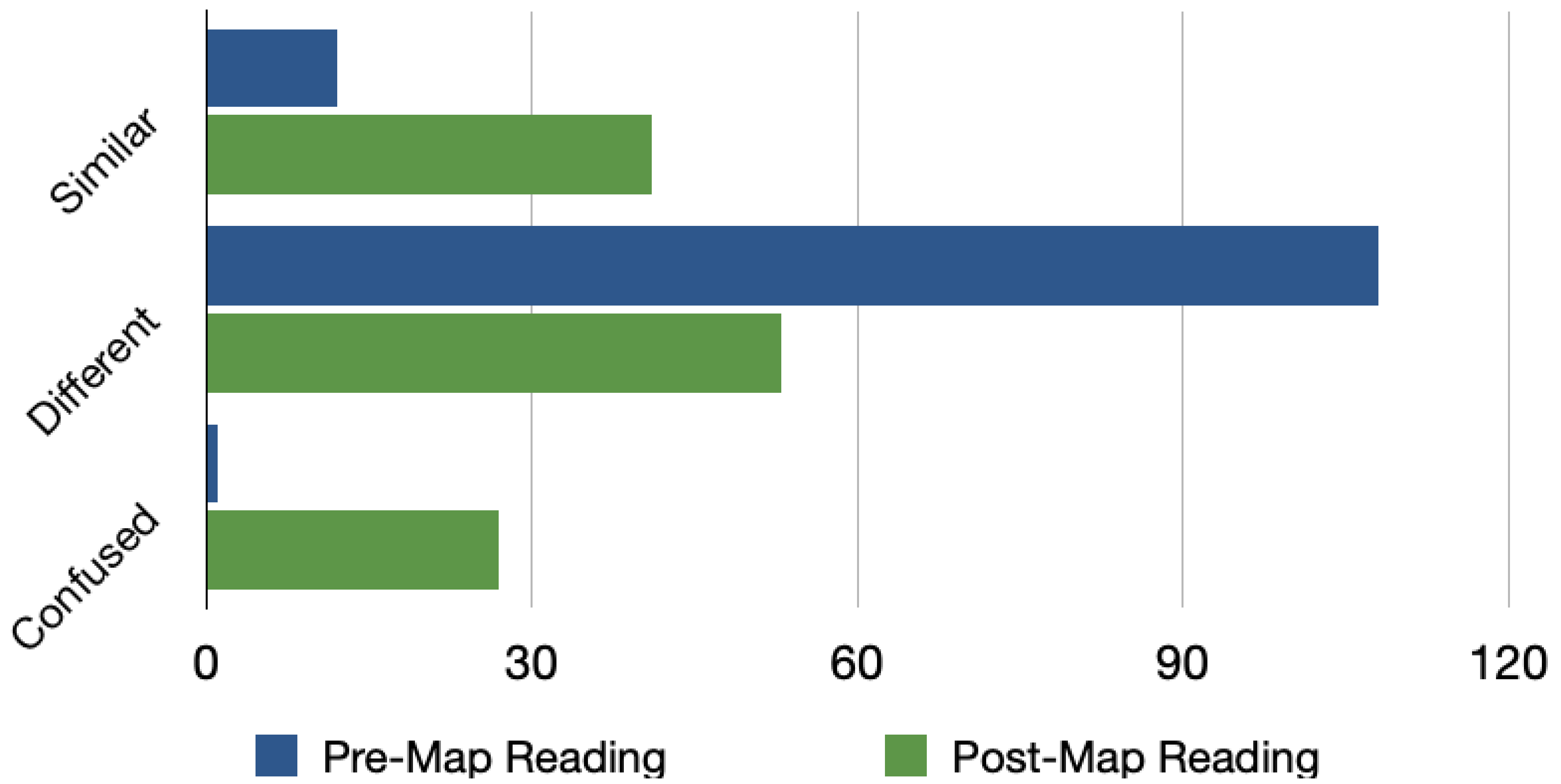


Figure 12 Respondents' Perceptions on the Most Frequent Disasters

From Figure 12 we can see that fewer participants had different answers to the question on the most frequent disasters after reading the map. More people got similar answers on the most frequent disasters with what was displayed on SIKK Magelang, however there are also more participants got confused after reading the map.

The McNemar-Bowker test revealed that the changes in perception on the most frequent disaster before and after the map reading, were not symmetrical χ^2 (3, N=121) = 52.471, p = 0.000.

Table 3

Effects of Map Reading on hazard knowledge

	#correct answers Pre-map reading	#correct answers Post-map reading	- Ranks	+ Ranks	Sig.	Effect of maps in raising hazard knowledge
1. Evacuation sites	73	41	36	4	0.000	Negative Direction
2. The most frequent disaster	12	41	3	32	0.000	Positive direction

• Perceptions on Risks of Multiple Hazards

Table 4 Statistics of Hazard Risk Perceptions Before and After Map Reading

Hazards	Pre-Map Reading			Post-Map Reading		
	Median	Mode	SD	Median	Mode	SD
Floods	2	2	0.711	2	2	0.528
Flash Floods	1	1	0.807	1	1	0.435
Landslides	1	1	0.797	1	1	0.469
Extreme Weather/ Storms	1	1	0.764	1	1	0.511
Droughts	2	2	0.567	2	2	0.258
Wildfires	1	1	0.818	1	1	0.414
Earthquakes	1	1	0.781	2	2	0.536
Volcanic Eruptions	1	1	0.000	1	1	0.000

- Overall, there were no changes in answers before and after reading the maps or using SIKK Magelang, except for the case of earthquake.
- The answers after reading the maps became more homogenous (lower SD).

- Perceptions on Risks of Multiple Hazards

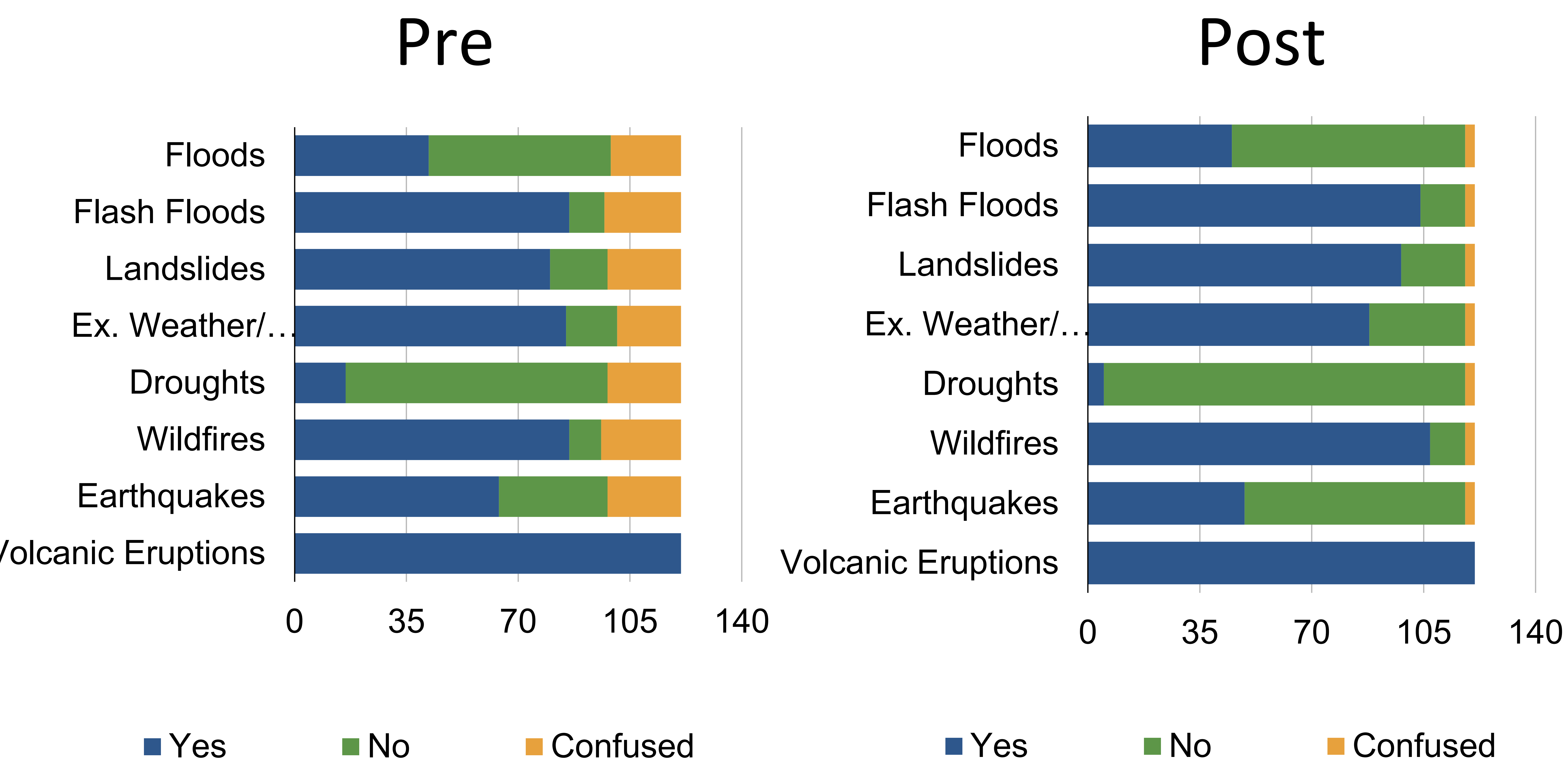


Figure 13 Perceived Risks on Multiple Natural Hazards Before and After Viewing the Maps

Table 5 Results of the McNemar - Bowker Test

Hazards	McNemar-Bowker		
	χ^2	df	Asymp. Sig.
Floods	18.086	3	0.000
Flash Floods	19.322	3	0.000
Landslides	18.364	2	0.000
Extreme Weather/ Storms	19.378	3	0.000
Droughts	25.299	2	0.000
Wildfires	20.225	2	0.000
Earthquakes	31.133	3	0.000

- The McNemar-Bowker test revealed that the changes in risk perception for all kinds of hazards except for the volcanic eruptions before and after the map reading, **were not symmetrical.**

• Perceptions on Risks of Multiple Hazards

How to measure?

The participant's house is part of flood prone areas as visualized on the maps, then he/she is expected to answer yes when being asked whether his/her house is at risk of flooding.

Before: If the participant checked yes, then the answer is "similar", other answers then will be classified as "not similar".

After: If the participant checked yes, then the answer is "similar", other answers then will be classified as "not similar".

Table 6 Results of the Wilcoxon Signed Rank Test

	#similar Pre-map reading	#similar Post-map reading	Negative Ranks	Positive Ranks	Sig.	Effect of maps in enhancing risk perceptions
Floods	43	45	12	14	0.695	Cannot be proven
Flash Floods	86	104	5	23	0.001	Positive direction
Landslides	80	98	13	31	0.007	Negative direction
Extreme Weather/ Storms	85	88	21	24	0.655	Cannot be proven
Droughts	16	5	14	3	0.008	Can be proven
Wildfires	86	107	10	31	0.001	Positive direction
Earthquakes	64	49	19	4	0.002	Negative direction
Volcanic Eruptions	121	121				Cannot be proven

Thank you for
your kind attention!