The Concept of Art in Thematic-Geological Map: Finding Informative-Like Visualization for Public

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Abstract

A two-dimensional geological map is handy to provide information about a state of the Earth's features such as a mountain, lake, river, settlement, and others. Nowadays, thematic-geological maps have become the most option to provide information on the dangers of natural disasters. However, civil society has a low interest in understanding the information in these maps provided by related institutions or agencies. By comparing various types of maps from government agencies and the technicality of the art information in visualizing, this paper explores how the thematic-geological map can be fascinating, engaging, and informative. Communicative natural hazard map upgrades the way of community-based disaster management. World historical trajectories of geological maps' development and best practices of people's risk perception of environmental hazards supported the paradigm and method for a better map presentation. As a result, this paper simulates a 2D thematic-geological map for the case study of the Bodebekkarpur Metropolitan Area, which is informative-like visualization for the public.

Keywords: geological map, urban geology, disaster, risk management

1 Introduction

A map means a two-dimensional graphic representation of the Earth's surface features in cartography, including the distribution of some phenomenon upon the specific geographic area (Visvalingam, 2011). Notably, a geological map exploring the characteristics of various rock types and any geological event of the area (Harrell & Brown, 1992). In response to recent decades' needs, the geological map has become a base map for many thematic purposes such as geotechnics, natural hazard, disaster, land use, hydrogeology, etc. The maps for these purposes, later known as the thematic-geological map.

As natural hazards endanger people's lives, in 1978, Munich Re's Geoscience Research Group published its first map of natural hazards in 1978 (Berz et al., 2001). Since then, many versions of natural hazard maps in many parts of the world, published by government agencies, private agencies, and academicians. In Indonesia, an official geological map and thematic-geological map released by the Geological Agency under the Ministry of Energy and Mineral Resources. The map is intended to be a decision aid for government, engineers, planners, professionals, private, society, or anyone interested in natural hazard problems so that precautions actions can be taken.

Despite its importance, civil society has a low interest in understanding the information in such maps. The technical presentation of the official map often not attractive but complicated. The use of symbols and color in the existing official maps is only understandable for certain people such as geoscientists and academicians. Local people find the map is too difficult to learn and digest. A study by Xu et al. (2020)

discovered that communicative natural hazard maps had been effectively upgraded the way of community-based-disaster management. The local authority government made an effort to translate the technical landslide hazard map into a fascinating, engaging, and informative map that has raised the people's awareness of natural hazards and disasters. This paper aims to translate how natural hazard maps can be communicative by engaging with the local people's risk perception and graphic art. Tracing the thematic-geological map's historical trajectories has supported the paradigm and practice for a better map presentation. In the end, the public version of the 2D thematic-geological map for the case study of the Bodebekkarpur Metropolitan Area has resulted as a product of simulation with the local people's perception.

2 Historical trajectories of thematic-geological map

Far before a geological map exists, at least rock or a stone has become the visual media to represent the shape of a city or any particular area. Is Smithsonian Institution recorded the journey of ancient city maps in a book entitled "Great city map – a historical journey through maps, plans, and paintings" (DK, 2016). Figure 1a. It shows how Rome's ancient city map was carved on a marble slab in c.205 CE. The map is in as hand-specimen size and with no scale. This map could not be adjusted, amended, and updated. However, the marble map is one of the earliest legacies of geology contribution in cartography. Later city map of Rome drawn in 1493, as shown in Figure 1b, has not specifically involved geological aspect. Still, the map tried to show the topography of the area, house as a scale, and figure out an outcrop at the right corner of the map. An earlier map of the Batavia (1669), as shown in Figure 1c, described the extension of *Groot Rivier Ciliwung* (Ciliwung River) ended in the Batavia Bay (called as estuarine in geology). This map has been using an index map at the bottom, as the present-day map.

As in 1726, Count Luigi Ferdinando Marsili developed the basic scientific principle of a geological map (Romano, Cifelli, & Vai, 2016). He sketched the lithology distribution in the Cesenate sulfur mines (Figure 2). He is the pioneer in the field of geology, geography, and cartography. Later in 1815, William Smith, an English surveyor, acknowledges as the one who has adequately mapped the geology of England, Wales, and southern Scotland. This area covers more than 175,000 km^2 (more extensive than Java Island in Indonesia). This map (Figure 4a) is marked as the geological map's birth (Sharpe, 2015).

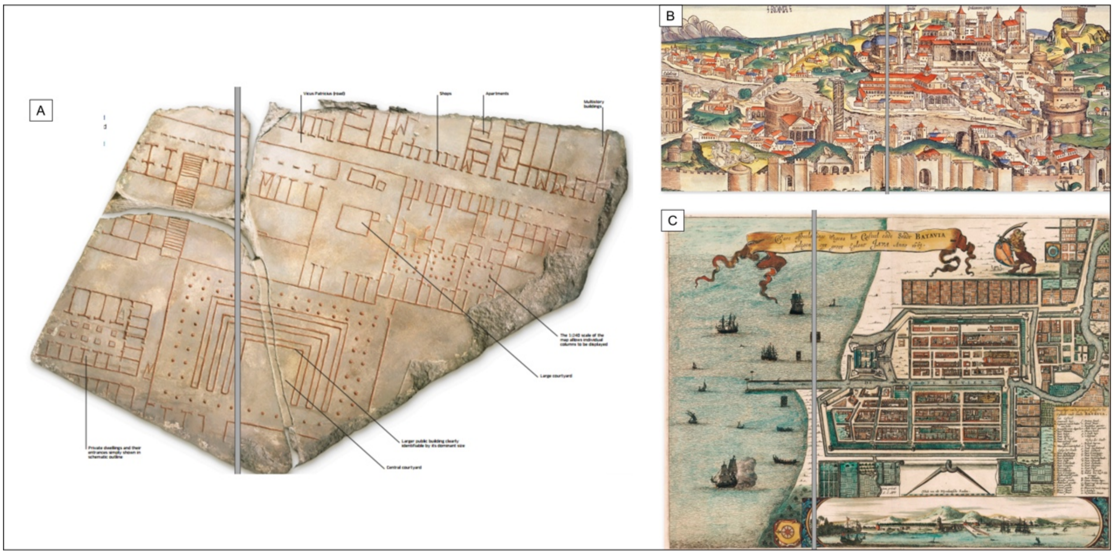

Figure 1 Ancient city maps containing geological symbol and value (A) the marble map of Rome, c.205 CE; (B) lowland and highland map of Rome, 1493 indicating topography; and (C) estuarine features of Batavia Bay, 1669 (modified from DK, 2016)

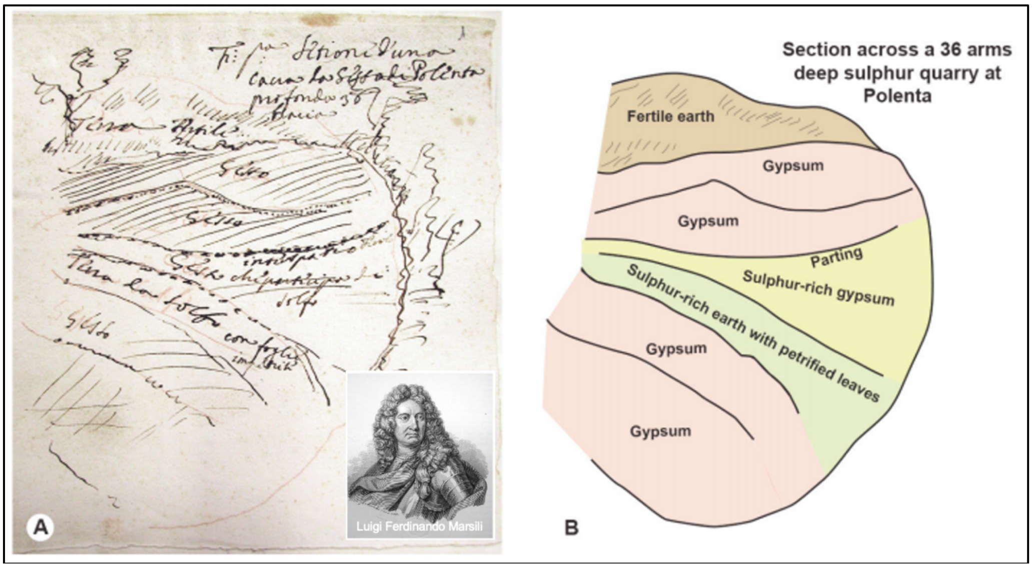

Figure 2 (A) The Marsili's sketch showed the rock units in the Cesenate sulfur mines, and (B) illustrated a map version of the drawing. The map was not adequate as a geological map, although many geologists have been inspired by it. Insert: The Count Luigi Ferdinando Marsili portrait (Romano et al., 2016)

3 Methodology

This paper uses the literature study method by technically comparing and compiling information from maps published from various studies—this information to be visualized as more informative and more comfortable to understand by civil society. This writing stage consists of three steps as follows. The first step is to study literature on history and publications that have been published from 200 years B.C until now. The second step is to create a thematic map using a Geographic Information System (GIS) approach. These maps consist of geological maps, landslide vulnerability zones, liquefaction susceptibility maps, problematic clay distribution maps, and subsidence vulnerability maps for zoning areas of the most significant geological hazard vulnerabilities. The third step illustrates the geological hazard conditions in the form of images and language that are more straightforward so that non-geoscientists can understand and are interested in seeing the illustration of the geological hazard vulnerability map. Figure 3 shows the flowchart of the research methodology.

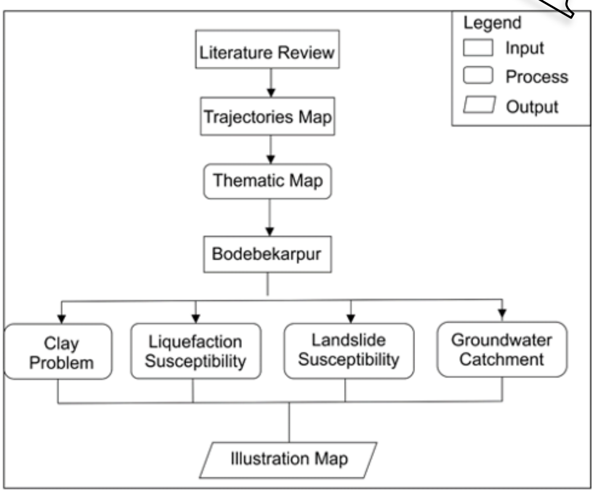

Figure 3 Flowchart of research methodology

4 Results and Discussion

A GIS map of the geologic unit and structural features in the Bodebekkarpur (Bogor-Depok-Bekasi-Karawang-Purwakarta) metropolitan area is shown Figure 4b. The primary source of the data is USGS (United States Geological Survey) base maps. Comparing the geological map by Smith in 1815 (Figure 4a) and the present-day geological map (Figure 4b), about two hundred years after the first geological map was released, there are no significant differences between them. Each map displays contour, scale, north direction, symbol, color represents different rock units and rock boundaries. Geological maps become a base map to create a thematic map, such as a hazard susceptibility map. In the case of Indonesia, the hazard susceptibility map was first initiated in early 2004.

In Indonesia, an official thematic geological map is released by the geological agency of the ministry of energy and mineral resources. Below are the examples of the official liquefaction susceptibility map in West Java (Figure 5a) and the official landslide susceptibility map in Bandung Regency (Figure 5b). The information provided in the maps is precious to manage a disaster risk vulnerability. Unfortunately, people's responses to such information are minimal due to a lack of understanding and interest in the map's display.

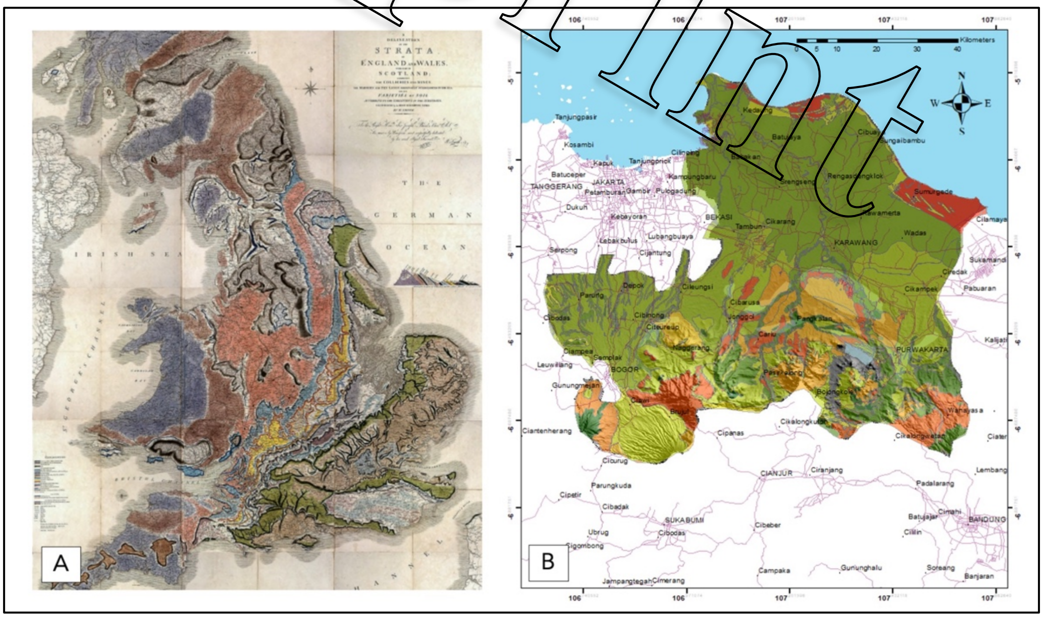

Figure 4 Comparison between (A) Smith's map 1815 – the geology of entire England, Wales, and southern Scotland – claimed as the first geological map in the world and (B) Geological map of the Bodebekkarpur Metropolitan Area (2020).

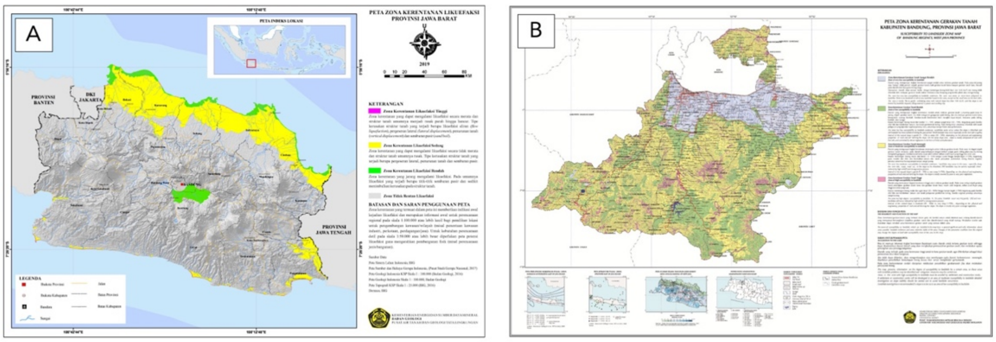

Figure 5 Model of (A) Liquefaction susceptibility map and (B) landslide susceptibility map released by the Geological Agency

4.1 Best practices in the world

Better map presentation following the local people perception's on natural hazard vulnerability will make the map interesting and informative. Communicative natural hazard map has effectively upgraded community-based disaster management (Xu et al., 2020). Inspiration comes from the indigenous people's community on the border of the Himalayas. Landslide vulnerability in the Kashmir and Turtuk area has been very high. Instead of geological conditions, extreme topography, extreme climate, and poverty have raised its exposure. Geologists' concern by making a geological hazard map of Turtuk can be seen in Figure 6. The locals later interpreted this technical map in the form of a local map. Both woman and man community have their perception regarding the map (Figure 7). Participatory Rural Appraisal (PRA) for the case study of landslide hazard vulnerability in the Turtuk area has been effectively running well.

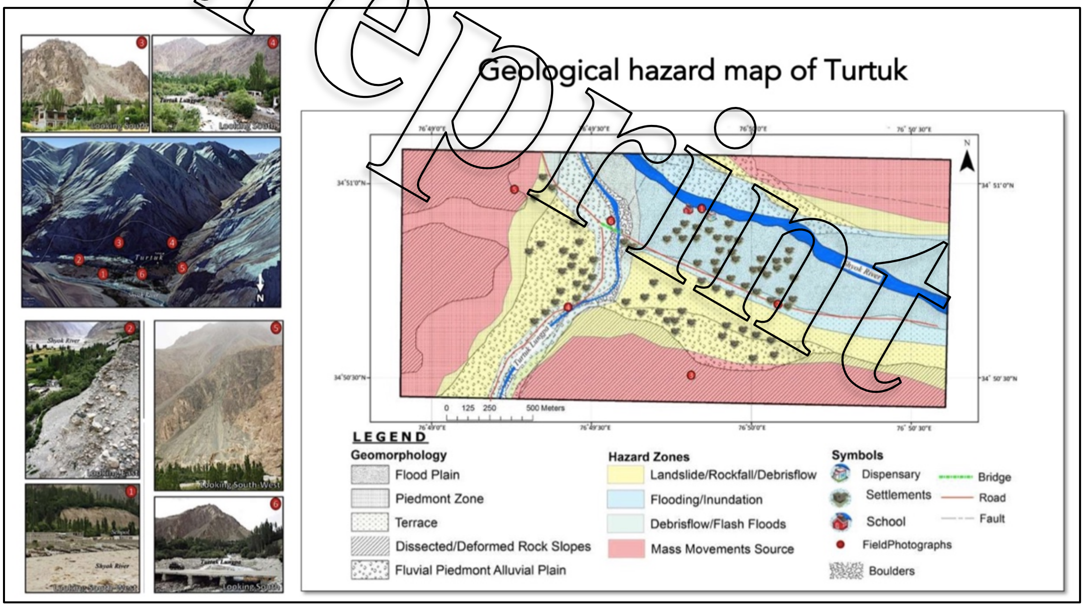

Figure 6 Geological hazard map of Turtuk – version from scientist and government (Ahmed et al., 2019)

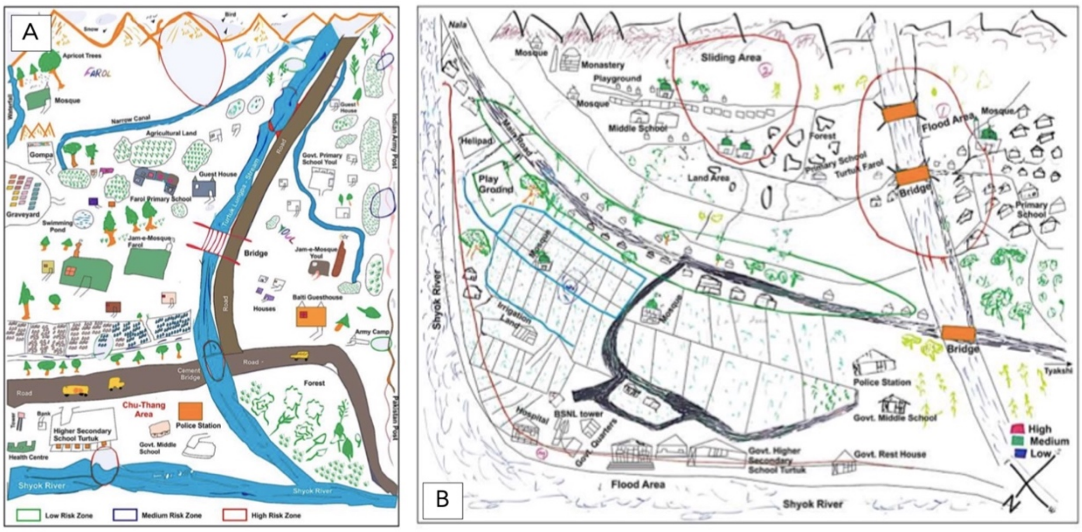

Figure 7 (A) Hazard map (not to scale) prepared by the Turtuk local community women group, and (B) Hazard map (not to scale) prepared by the Turtuk local community man group (Ahmed et al., 2019)

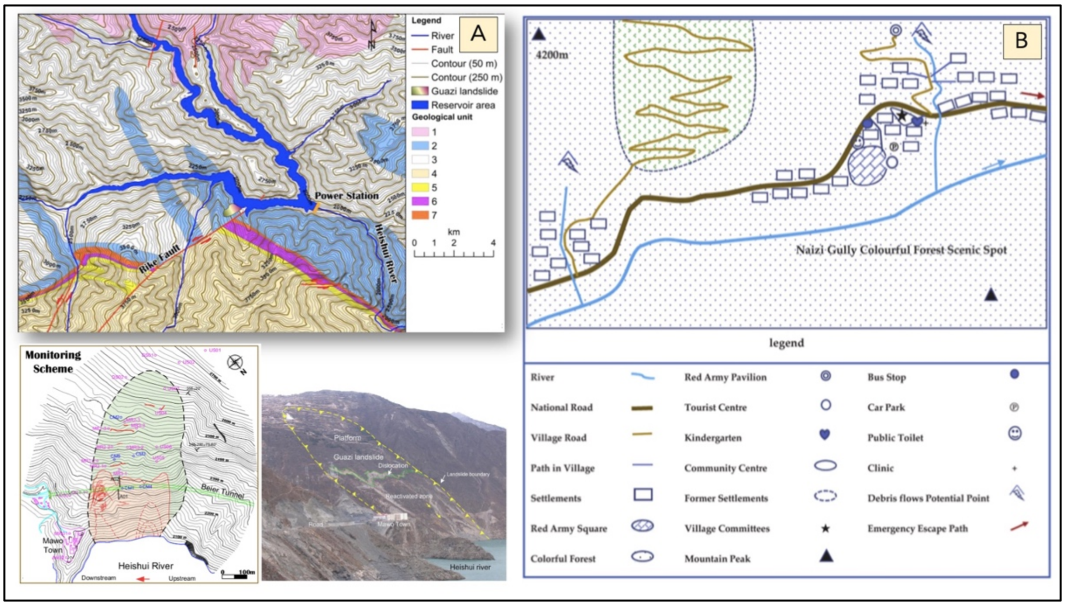

Figure 8 (A) Landslide hazard vulnerability map around Guazi landslide, Heshui County, Sichuan. (B) Local perception map of the existing map as in Fig. 8a, as a result of PRA (Xu et al., 2020)

Another best practice of PRA (Participatory Rural Appraisal) applied at Heshui county, Sichuan Province, China. The Guazi landslide at this area, located explicitly around Mawo Town on the right bank of the Heishui River, which is 19 km upstream from the urban area of Heishui County, is an ancient landslide which is reactivating recently due to the construction of a hydroelectric power scheme downstream (Zhao et al., 2019). The local authority and academicians' effort to update the geological condition of the area around the Guazi landslide is shown in the following geological map (Figure 8a). The map showing detail contour, fault, and detail rock unit will only be caught up for certain people (geoscientist, geographer, surveyor) but not the local one. In the context of Disaster Risk Management (DRM), Xu et al. (2020) involving local community participatory in Heshui County to adopt their perception of the existing landslide hazard susceptibility map of the area. As a result, a sketch of a map of settlements in Heshui County was reproduced in collaboration between the community and scientists (Figure 8b).

Best practices in both vulnerable hazard areas, either Turtuk and Heshui County, have raised the people's awareness of how to prevent and respond to any potential disaster in the area. As targeted to geological disaster prevention and disaster risk management (DRM), transforming the idea of a particular natural hazard map into community perception of risk and vulnerability to environmental hazards (PRA) involving art and informative-like visualization is most-likely effective and applicable.

4.2 Informative-like visualization for natural hazard map of Bodebekkarpur Metropolitan Area, Indonesia.

According to the Local government act no. 12 of 2014, Bodebekkarpur Metropolitan Area is a unit of urban areas formed due to agglomeration of economic activities and social activities cover about 314.840 hectares. Regional geology of these areas surrounding two zones. They are the plains of the Jakarta coast zone and the Bogor zone. The plains of the Jakarta Coast zone extend from the western tip of Java Island to the east, following the north coast of West Java to Cirebon city, with a width of about 40 km. This area generally has a flat morphology, mostly covered by river sediment and partly by young volcanic lava. In contrast, the Bogor zone is located at the south of the Jakarta coastal plain. This area extends from west to east through the City of Bogor, Purwakarta, to Bumiayu in Central Java. This zone generally has a hilly morphology (Van Bemmelen, 1949).

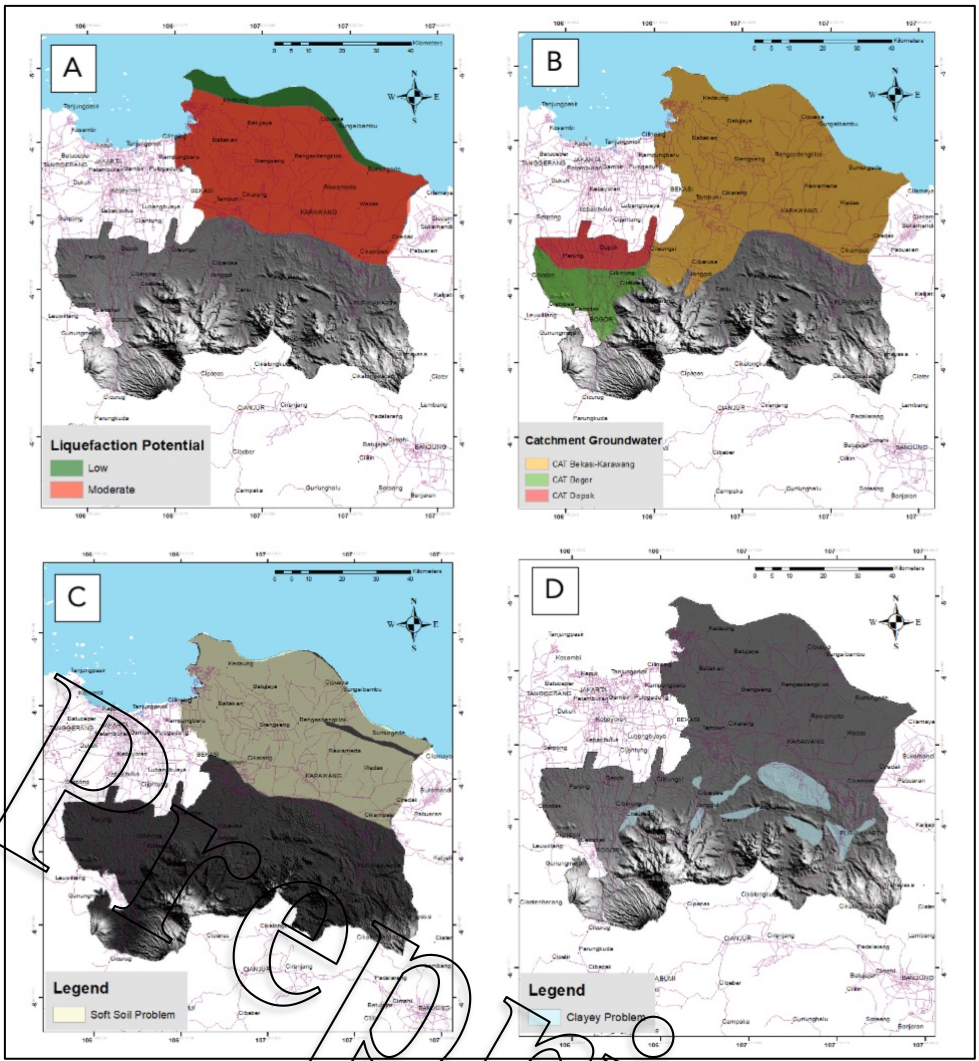

Figure 9 (A) Liquefaction susceptibility map, (B) groundwater catchment map, (C) soil map, and (D) clay map of the Bodebekkarpur Metropolitan Area.

In this paper, four different thematic-geological hazard maps of the Bodebekkarpur Metropolitan Area were processed using GIS. The maps are liquefaction susceptibility map, groundwater catchment map; soils map; and clay map (Figure 9). Groundwater catchment map (Figure 9b) informs that since Bekasi and Karawang are located in the low land area, these areas have sufficient groundwater reserves compare to the hilly part as in the Depok, Bogor, and Purwakarta. However, Karawang and Bekasi's position in the lowland surrounded by high topography makes Bekasi and Karawang more vulnerable to flooding. As portrait in Figure 9a,9c, and 9d - the soft soil and clay composition indicate the liquefaction vulnerability in the northern part of the Bodebekkarpur Metropolitan Area is higher than in the southern region. In other words, Bekasi and Karawang, except the coastal parts, are more vulnerable to liquefaction compare to Depok, Bogor, and Purwakarta. Even though the last-mentioned areas are relatively secure from liquefaction hazards, extreme topography in the southern part makes it vulnerable to landslide hazards.

Putting art and informative-like visualization to transform the maps will make the information as above can be easily understood by the civil society in the area (Figure 10-11). Further, natural hazard and disaster awareness from communities in the Bodebekkarpur Metropolitan Area expected to rise and supported the preventive action by the BMKG or BNPB agencies.

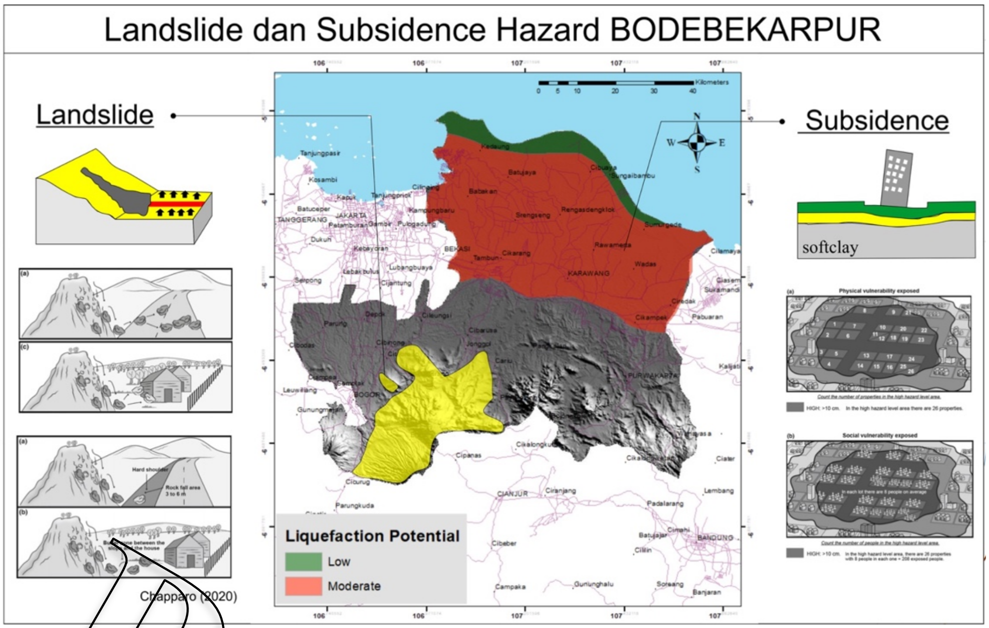

Figure 10 Combining the information as in the hazard base map of the Bodebekkarpur Metropolitan Area and the illustration by Chapparo & Carlos (2020)

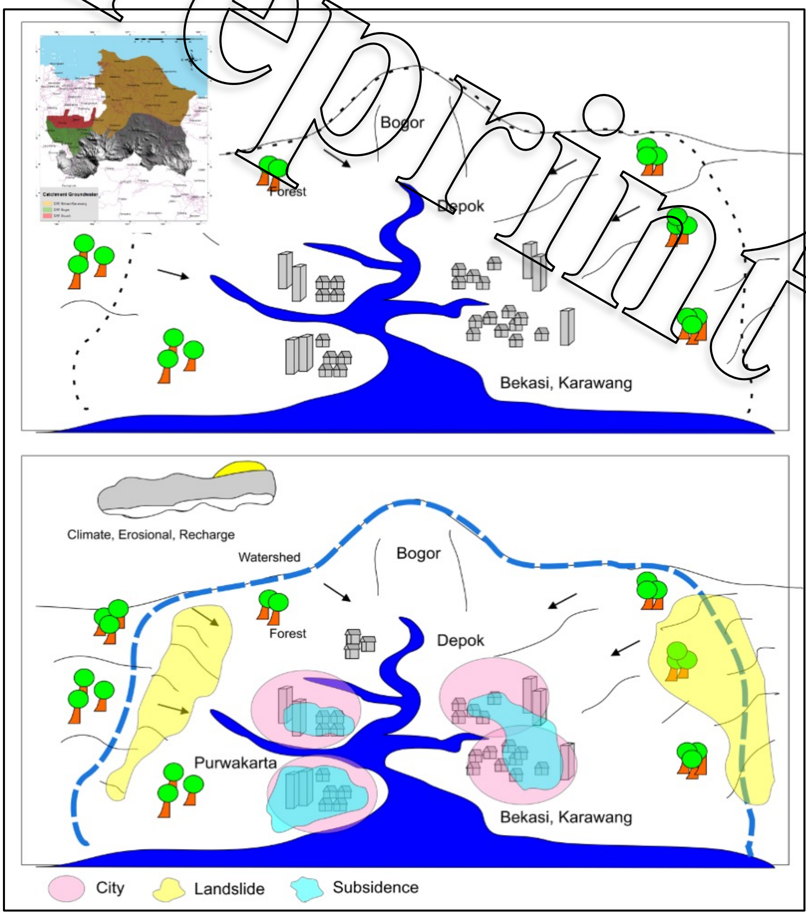

Figure 11 A visual art map transforming from the four different thematic-geological maps of Bodebekkarpur Metropolitan Area

5 Conclusions

It is a real challenge for scientists and the government to transform the thematic-geological hazard vulnerability map into a local perception map through Participatory Rural Appraisal (PRA) scheme. However, best practices in the world such as in Turtuk, the border of Himalaya, and in the Heishui County, Sichuan that putting art into the map following the local people perceptions have successfully raised the awareness of the civil society that helps to prevent and respond from the hazard, in term of disaster-risk management (DRM). Such practices should be applied in both rural and urban parts of Indonesia. The complex geological condition, climate, and high weathering rate have put many dense human population areas vulnerable to natural or geological hazards. This concept might reduce the potential loss of life and value in the future.

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