Updating the slope-movement data on the Batu-Kediri road network using digital information

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Abstract. Updating the landslide data or slope movement on the road is needed for the safety of traffic movements. Landslide events on the road must be compiled to measure their characteristics, including the causes thereof. In identifying and assessing landslide events, detailed data related to trigger parameters, time of occurrence, impact, or material loss are absolutely necessary. The utilization of digital media ultimately provides very useful disaster data. However, these data sources have different levels of information depth. To obtain sufficient data to analyze landslides, the data must be sorted according to the depth classification of information. The classification is based on landslide coordinates, impacts on traffic movement, time of occurrence, fatalities, triggers, information providers, and types of landslide material. By utilizing the digital media, updating the record of landslides between 2008-2020 resulted in landslide density values as follows: Batu Municipal 9.93 (n/km), Pujon 3.44 (n/km), Kasembon 1.46 (n/km) and Ngantang (0.91 n/km).

1. Introduction
The rapid growth of online media users or social media is a special phenomenon in the industrial era 4.0. Internet-based media can change behaviours as well as human phenomena in sharing information. Before internet-based media was used, existing information was obtained through media giant companies, so now in the 4.0 era, information can be sourced from anywhere without going through information filters. The positive and negative sides of the phenomenon are dynamics that can be utilized according to the objectives of the users.

Today, disaster occurrence becomes a concern to the community. Both in the forms of occurrence are triggered by natural and non-natural disasters such as technology failure. In all phases of a disaster occurrence, starting from the pre-disaster stage to the post-disaster phase, communication is a determining factor for the success of risk / impact reduction efforts. Rudianto (2012) underlines the accuracy of disaster information. Miscommunication actually worsens the condition of all parties impacted and involved in disaster relief.

The disaster risk reduction program is a top priority as a result of changes in the dynamics of regional growth. Development of the city, the pace of urbanization, and the level of poverty are the foremost challenges faced. Disaster management is more multidisciplinary, a multi-approach, as well as using leading technologies. Disaster institutions are known to be generous in presenting results and data analysis. These data when combined with information that is spread online and social media will be very useful if applied as a source of research information for mitigation activities.
Slope movement on roads has a significant social and economic impact. Damage and loss are generally quite large because the road is an economic link chain. Landslides on the road these days can be easily recorded through uploading activities of the community and institutions through social media. The data obtained are generally above 2008, where online media have begun to stabilize and are well established in presenting the information.

2. Literature review
Prajarto (2007) states that the enthusiasm of the media in broadcasting disaster events has two sides of an impact on society. On the one hand, the disaster information system seeks to be strengthened by the role of the media in the disaster information system. However in practice, instead of getting integrated information in a complete disaster information system, the public will only get a collection of pieces of information about disasters. Wahyudianto (2019) also stated that Crowd-source as well as online media in this case also becomes an important part of the disaster information systems. Those data need to classify and be grouped into several technical criteria. In addition to providing information in a fast tempo, the information conveyed by these media becomes a cover for weakness when official sources do not release the official information. Data that can be traced through an internet search engine is useful as an alternative source of disaster information for analytical purposes. Wahyudianto (2017) used the internet as an alternative source of information to analyze landslides on roads since 2007-2016. Likewise, Floris et al. (2011) conducted a landslide vulnerability assessment using online data in the Veneto region, Italy.

2.1. Slope-movement mitigation on roads
Mitigation of landslides on roads has been carried out by many researchers. Wahyudianto (2019) made a landslide hazard map on the Ponorogo-Pacitan road network, East Java, and validated the results using a landslide inventory field survey on the impact of slope movements due to the Cempaka Cyclone disaster. Guzzetti (2005) adopted Pierson & van Vickie (1993) in assessing the hazard of falling rocks on a road. Likewise, Prina (2004), Parise (2002), Gaurav (2009), and Liu (2006) formulated the vulnerability of vehicle movements based on the probability of the existence of vehicles spatially on a road segment. Approaches related to calculating rockfall risk are standardized by AGS (2010) in Australia, while Dorren (2009) who conducted research on the national road network in Switzerland approached the risk value of vehicle movements based on certain financial values based on the probability of fatalities on road users. Wahyudianto (2017) uses a combined approach, which maps the frequency analysis of landslide events using the method of Huang (2015) which was modified as a result of zero short-duration rain data, and replaces it with daily rainfall. Wahyudianto (2017) calculates the boundary line of the rain trigger for the landslide using the modified Huang (2015) method as a result of zero short-duration rain data and replaces it with daily rainfall.

Figure 1. Batu-Kediri provincial road network

2.2. Slope-movement data search
Collecting landslide data on internet-based media has its own advantages, given the ability of search engines to track information is quite well in the past few years. The data generated via the internet have varying degrees of accuracy. There are data that record slope movement through the date of the occurrence, time period, even some of them are very detailed in recording the time of the disaster event, the type of slope movement material, a brief analysis of the cause of the event, as well as the impact caused by the slope movement occurrence. The process of searching data uses the internet search engine as figured in Figure 2.

Wahyudianto (2017) validated internet information sources related to landslide events on his research road as many as 65 sources, with details of 50 days and 92 landslides. The level of accuracy varies. As much as 67% of information was managed to record the time of the occurrence, while the remaining 33% did not know the time of the disaster occurrence.

Figure 2. Search for landslide information

3. Research methods
Information that has been collected through the internet is filtered to find important information related to the slope movement. The information includes the day of events, hours, location, quotation of information sources, the impact of traffic movements, type of material, cubic of material, and other information deemed necessary for further analysis. Collecting records of landslide events in this study continues the research of Wahyudianto (2017) and Wahyudianto (2019) as an effort to update the record of occurrence. Wahyudianto (2017) collected data between 2007-2016, whereas Wahyudianto (2019) made an effort to update the data completed until March 2019. From the renewal efforts carried out by Wahyudianto (2019), there were obtained 84 data sources with details of the occurrence of 69 days and 114 landslides. Updating data in this research is completing search results until June 2020.

4. Results and discussions
Mapping slope movement using internet media has an easy source of information. From the data updating process until June 2020, it can be concluded that the pattern of landslide occurrence based on the distribution of the month has slightly changed. If previously the majority of landslides occurred in January and February contributed 80.71% for 12 years of recorded events (Wahyudianto, 2019), then for 13 years of the occurrence, contributions in January and February decreased. The contribution of occurrence in January and February to the end of the search in June 2020 was 76.43% as listed in Table 1. There are four most important rainy months which contributed a lot to slope movements. The months are December, January, February, and March. Wahyudianto (2019) calculated that these months contributed 93.04% of occurrence. Meanwhile, of the results of the renewal process, these months contributed as much as 91.87% of occurrences as listed in Table 1 and Figure 4.
Update of slope movement occurrence record data from 2019 until June 2020 is 9 sources of information, with details of 9 days of occurrence and 9 landslide points. The percentage of hours of the occurrence of all collected data is 30% for the unknown and 70% for the known as listed in Table 3. Of the distribution of landslide events on a yearly basis, most of the disaster events occurred in 2013 and 2014 or amounted to 49.59% as listed in Table 4. The slope movement data that have been recorded from 2007 until June 2020 are 93 sources, with the details of the occurrence are 78 days and 123 location points. The slight change of the slope movement occurrence is assumed as the function of the change of rainy season and rainfall distribution during the months.

5. Conclusions
The results of landslide occurrence that are positioned in the administrative area of the sub-district obtained values of landslide density representing the hazard level of a road segment. The results of the landslide density data updated by Wahyudianto (2019) were in Batu Municipal of 9.27 (n / km), Pujon of 3.08 (n / km), Kasembon (1.46 n / km) and Ngantang (0.85 n / km). From the update record of occurrence between 2007-2020, the largest landslide density value is in Batu City, 9.93 (n / km), followed by Pujon (3.44 n / km), Kasembon (1.46 n / km), and Ngantang (0.91 n / km) as listed in Table 2. From the results of the analysis, it can be concluded that the update data landslide point is the location of the old landslide point in the slope cutting zones. This proves that the influence of the occurrence of a mass movement on the road slope is more contributed by slope cutting than the cumulative rain.

Table 1. Distribution of slope movements on the Batu-Kediri road network during 2007-2020

| No | Month | D, days of Occurrence | n, number of landslide points | % D | % n |
|----|-------|-----------------------|------------------------------|-----|-----|
| 1  | Jan   | 24                    | 49                           | 30.77 | 39.84 |
| 2  | Feb   | 27                    | 45                           | 34.62 | 36.59 |
| 3  | Mar   | 13                    | 14                           | 16.67 | 11.38 |
| 4  | Apr   | 2                     | 2                            | 2.56  | 1.63  |
| 5  | May   | 0                     | 0                            | 0.00  | 0.00  |
| 6  | Jun   | 1                     | 2                            | 1.28  | 1.63  |
| 7  | Jul   | 2                     | 2                            | 2.56  | 1.63  |
| 8  | Aug   | 1                     | 1                            | 1.28  | 0.81  |
| 9  | Sep   | 0                     | 0                            | 0.00  | 0.00  |
| 10 | Oct   | 1                     | 1                            | 1.28  | 0.81  |
| 11 | Nov   | 2                     | 2                            | 2.56  | 1.63  |
| 12 | Dec   | 5                     | 5                            | 6.41  | 4.07  |
| Σ  |       | 78                    | 123                          | 100.00 | 100.00 |

Table 2. Distribution of slope movements by sub-districts during 2007-2020

| Sub-district | Batu | Pujon | Ngantang | Kasembon | Σ Sum |
|--------------|------|-------|----------|----------|-------|
| n, number of landslide occurrence | 45   | 48    | 14       | 16       | 123   |
| n (%)        | 37%  | 39%   | 11%      | 13%      | 100%  |
| n per year   | 3.46 | 4.36  | 1.27     | 1.45     | 11.18 |
| Length, L (km) | 4.53 | 13.97 | 15.34    | 10.94    | 44.78 |
| n/L, density (n/km) | 9.93 | 3.44  | 0.91     | 1.46     | 2.75  |

Table 3. Level of depth information on slope movement data during 2007-2020
Table 4. Distribution of slope movements by years of occurrence during 2007-2020

| Year          | D, day of occurrence | n, number of occurrence |
|---------------|----------------------|-------------------------|
| 2020, Jan-June| 5                    | 5                       |
| 2019          | 5                    | 5                       |
| 2018          | 9                    | 11                      |
| 2017          | 9                    | 10                      |
| 2016          | 10                   | 12                      |
| 2015          | 2                    | 2                       |
| 2014          | 11                   | 35                      |
| 2013          | 16                   | 26                      |
| 2012          | 4                    | 4                       |
| 2011          | 2                    | 5                       |
| 2010          | 3                    | 6                       |
| 2009          | 0                    | 0                       |
| 2008          | 1                    | 1                       |
| 2007          | 1                    | 1                       |
| Σ             | 78                   | 123                     |

Figure 3. Landslide distribution based on the months of occurrence (2007-2017) by Wahyudianto (2017)

Figure 4. Landslide distribution based on the months of occurrence (2007-2020)
Concrete cracking is known to have a knock-on effect on the durability performance and long-term

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References
[1] Rudianto 2015 Komunikasi dalam Penanggulangan Bencana *Jurnal Simbolika* 1 52 L 2
[2] Prajarto N 2007 Bencana, informasi dan keterlibatan media *JSP* 11 3 (Yogyakarta: UGM)
[3] Wahyudianto E 2019 Pembangunan infrastruktur jalan dalam era teknologi industri 4.0, inventarisasi bahaya longsor jalan pada fase pasca bencana (studi kasus siklon cempaka pada jalan provinsi di Kabupaten Pacitan) *Prosiding Konferensi Nasional Teknik Jalan ke-10* 513 L 13
[4] Guzzetti F, Dikau R and Glade T 2005 *Landslide hazard and risk assessment* (Bonn: Mathematich-Naturwissenschaftlichen Fakultät Rheinischen Friedrich-Wilhelms-Universität Bonn)
[5] Pierson L A and Vickle R V 1993 Rockfall hazard rating system participants manual *Report FHWA-SA-93-057*
[6] Prina E, Bonnard C and Vulliet L 2004 Vulnerability and risk assessment of mountain road crossing landslide. *Riv. Ital. di Geotec.* 2 p 76
[7] Parise M 2002 Landslide hazard zonation of slopes susceptible to rock falls and topples *NHESS* 2 p 42
[8] Gaurav K, Saran S, Stein A and Das I 2009 *Stochastic modelling of land cover (dynamic) elements* Thesis ed. Dehradun (India: Indian Institute of Remote Sensing (IIRS) and International Institute for Geoinformation Enschede, The Netherlands)

[9] AGS 2000 *Landslide Risk Management Concepts and Guidelines* (Sydney: Australian Geomechanics Society: Sub Committee on Landslide Risk Management)

[10] Dorren L, Sandri A and Raetzo H 2009 *Landslide Risk Mapping for Entire Swiss National Road Network* (Bern, Switzerland: Project "Naturgefahren auf National Strassen" NHNR National Hazard on National Roads FEDRO (Federal Road Office) & FOEN Federal Office for the Environment)

[11] Wahyudianto E 2018 Analysis and risk study on landslide hazard frequency at road corridor of Batu City–Kediri Regency border *JCEF* 4 p 3

[12] Wahyudianto E 2019 Pembangunan infrastruktur jalan dalam era teknologi industri 4.0, asesmen bahaya longsor pada jalan raya berbasis data crowd-source dan media online (studi kasus ruas jalan Kota Batu-batas Kab. Kediri) *Prosiding Konferensi Nasional Teknik Jalan ke-10* 64 L 2

[13] Huang J, Ju N P, Liao Y J and Liu D D 2015 Determination of rainfall thresholds for shallow landslides by a probabilistic and empirical method *NHESS* 15 p 2715-21