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Distribution and Analysis of Responses to Extreme Weather Phenomena through Twitter

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Abstract

The aim of this research is to map the distribution of extreme weather events occurring in Indonesia through Tweets, which are subsequently validated with actual conditions, and to analyze the public sentiment regarding extreme weather. The research utilizes the Social Network Analysis (SNA) method, obtained from the netlytic.org website. Data collection was conducted for five days, from March 23 to March 27, 2023. However, only 249 tweets, or approximately 31% of the total, were related to extreme weather, specifically stormy rain phenomena in their true sense. The stormy rain phenomena were identified to have occurred on March 23 and March 27, 2023. There was also a hailstorm phenomenon in Pekanbaru, Riau. The highest occurrence of extreme weather events was recorded in several regions of Indonesia, including Bandung, Surabaya, Malang, Jakarta, and Riau. Most Twitter users' responses were negative (49%), followed by neutral responses (45%), and positive responses (6%).

Keywords: extreme weather; twitter; netlytic; rainstorm; hail

Introduction

Indonesia is located on the equator, resulting in a high average rainfall. The latitude of Indonesia is on the equator and its geographic location between continents and oceans gives it a strong character in terms of climate. Indonesia experiences sunlight throughout the year and has varied annual rainfall (Haryoko & Gunawan, 2022; Setiawan, 2021). The interconnection between geographical location, topography, island structure, and island orientation significantly influences Indonesia's weather and climate systems (Wirjohamidjojo et al., 2010; Prasetyo et al., 2021).

The analysis of the rainy season by the Meteorology, Climatology, and Geophysics Agency in November 2022 revealed that the overall regions of Indonesia experienced rainfall that was wetter than normal, with an excess of 41.01% (Haryoko & Gunawan, 2022). The agency further stated that in April, there is a high probability of rainfall exceeding 300 mm/month in certain areas, including Aceh, West Java, Central Java, Central Kalimantan, East Kalimantan, North Kalimantan, South Sulawesi, Central Sulawesi, West Papua, Maluku, and Papua (Prasetyaningtyas, 2023).

Extreme weather occurs when unusual natural phenomena increase, resulting in increasingly extreme weather and climate conditions. The impacts of climate deviations, such as increased rainfall, flash floods, storm surges, local storms, urban heat island effects, droughts, and landslides, are becoming more evident (Caraka, et al., 2015; Mananohas et al., 2019). The National Disaster Management Agency (BNPB) states that over 98% of disasters in Indonesia are hydro-meteorological disasters, with a total of 1,344 flood events in 2022 (Rohmah, 2023).

Communication in the context of disasters is not only necessary during emergencies but also crucial before and after the occurrence of a disaster (Rudianto, 2015; Lestari et al., 2018). Broadcasting news through media serves to disseminate various information, including information related to natural disasters. Competence in

communication is crucial in sharing and accessing accurate disaster-related information (Senova, 2016). Various social media platforms have become a channel to disseminate and obtain information quickly and easily.

The trend of social media usage in Indonesia has been increasing in recent years, with over 160 million social media users in 2021. Indonesia's most popular social media platforms are WhatsApp, YouTube, Facebook, Instagram, and Twitter (Kemp, 2021). According to a survey by Hootsuite and We Are Social in 2021, more than 98 percent of internet users in Indonesia access social media through smartphones, and around 43 percent of social media users spend more than three hours per day using social media (Riyanto, 2021).

The Twitter platform provides convenience in reading, writing, and gathering data that contain temporal and spatial information (Hernandez-Suarez et al., 2019). Twitter users can share information about current weather conditions in a location, the severity of a hydro-meteorological disaster, and provide actions and support to disaster victims. Twitter users can respond as a form of emotional perception towards a phenomenon that occurs. However, Twitter users can also obtain information from various sources, including unreliable sources, which can influence the public's understanding and perception of an event. The post-truth era poses a challenge for society to increase vigilance amidst the proliferation of fake news, especially in relation to disaster mitigation.

The purpose of this research is to determine the patterns of distribution of extreme weather events in Indonesia through tweets, which will be further validated with actual conditions, and to analyze public sentiment and perception regarding extreme weather. This is done as a preventive measure for disasters, which can then be followed by efforts to improve mitigation management and increase public awareness of extreme weather. Disaster management should be supported by various approaches, one of which is to enhance community preparedness to reduce disaster risks (Rudianto, 2015).

Methods

This research utilizes the Social Network Analysis (SNA) method. Social Network Analysis (SNA) is a theoretical and methodological approach to studying various social systems by analyzing data to identify local and global network structures and dynamics, with the goal of uncovering patterns of human interaction. This method is used to analyze and depict social network structures. It can be applied at both micro and macro levels and can also be employed to examine networks formed across different platforms or categories (Gruzd et al., 2016; Huang, 2022; Setiamukti et al., 2023).

Social Network Analysis (SNA) can be utilized to analyze the flow of information on Twitter during extreme weather events and comprehend the characteristics of social media networks during emergency responses (Chatfield & Brajawidagda, 2012; Kim & Hastak, 2018). By examining the network structure or communication styles on social media, key actors and communities that play crucial roles in disseminating information during extreme weather events can be identified. The SNA method is employed to understand patterns of the distribution of extreme weather events in Indonesia through Twitter tweets.

The use of SNA method in this research is based on the netlytic.org website. Netlytic is a cloud-based online software platform that is designed to analyze text and social network patterns on social media. Netlytic can handle text analysis by extracting keywords and generating concise summaries of communal textual discourse within a dataset (Gruzd & Mai, 2023). By utilizing the Application Programming Interface (API) of social media platforms, this platform can automatically collect data and identify communication patterns within the social media data. Netlytic can be used to retrieve data from various social media platforms such as Twitter, Facebook, YouTube, and Instagram (Anggreni et al., 2019). Netlytic can be utilized for valid and reliable social media research, employing a multi-method approach that includes comparative analysis and the application of various techniques such as social media analysis, text mining, and social network analysis to examine online discourse and network data (Gruzd et al., 2016)

The data collection period lasted for 7 days due to the occurrence of heavy rain accompanied by strong winds, indicating extreme weather conditions. The total number of recorded tweets during the data collection process was 1,515. However, data was only collected for 5 days, from March 23 - 27, 2023 because in the last 2 days, original tweets related to the used keywords had significantly decreased. The data population used consists of 811 tweets with the keywords "hujan" (rain) and "badai" (storm) without any location restrictions. The keywords "hujan" (rain) and "badai" (storm) were chosen because they are familiar and widely known indicators of extreme weather conditions (Muzaki, 2021; Nugroho, 2019) among the public. Consequently, numerous tweetss containing both "hujan" (rain) and "badai" (storm) can be found in a single post, indicating that there is extreme weather occurring in that particular area. The analyzed tweets are only those containing the keywords "hujan" (rain) and "badai" (storm) within a single tweet to avoid biases from keywords that do not necessarily indicate extreme weather phenomena, for example the keyword "hujan" which may not always signify extreme weather.

The variables in this research include occurrences of extreme weather, which will be combined with information from various mass media sources. The next variable is the distribution pattern of extreme weather events, specifically rain and storms, as well as the public's responses uploaded through tweets, which will be classified as positive, negative, and neutral. Only original response tweets will be processed. The output data obtained from Netlytic can be managed in Excel format, automatically indicating the text status (original, retweet, or reply). Netlytic only collects publicly available posts through public APIs of social media platforms. Personal data such as Twitter usernames and addresses are not disclosed; all data has been anonymized.

Results

Indentification of Extreme Weather Phenomena

Based on the collected data from March 23 to March 27, 2023, a total of 811 tweets were obtained using the keywords "hujan" (rain) and "badai" (storm). However, only 249 tweets, or approximately 31%, were related to extreme weather, specifically the phenomenon of rainstorms in its true sense. There were 562 unique tweets with the keywords "hujan" and "badai," accounting for approximately 69% of the total tweets, which could not be included in the data analysis process as depicted in Figure 1 below.

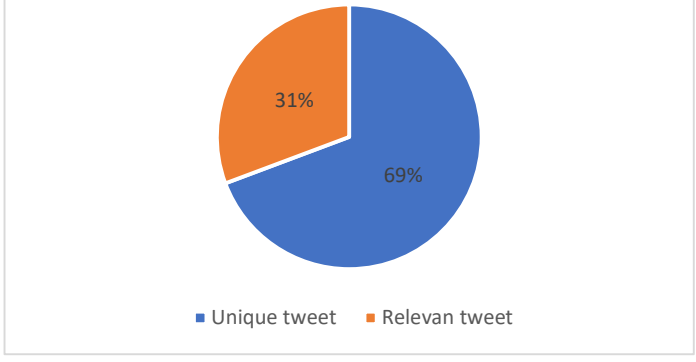

Figure 1. Comparison diagram of Tweets

Figure 1. illustrates a comparison of the number of relevant tweets (relevant tweets) and irrelevant ones (unique tweets) containing the keywords "hujan" (rain) and "badai" (storm) based on the number of tweets recorded in the Netlytic database during the research period. Unique tweets contain posts with the keywords "rain" and "storm," but not in their literal sense. Among these unique tweets are figures of speech and various posts that do not refer to the ongoing extreme weather events.

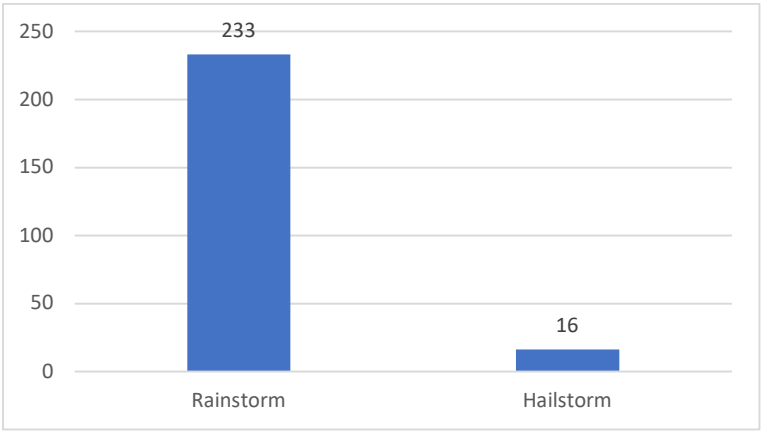

Figure 2. The Number of Rainstorm and Hailstorm Tweets.

Two types of extreme weather phenomena were identified namely rainstorms and hailstorms. Figure 2 represents the data collection diagram regarding tweets containing rain and storm, as well as hail. Based on Figure 2, it is evident that the number of Twitter users posting tweets with the keywords "rain storm" is higher compared to "hail storm." Tweets containing hail were only found for 3 days, specifically from March 25 to March 27, 2023. This discovery indicates that the phenomenon of hail was experienced by only a small portion of Twitter users, covering a limited geographical area and occurring over a shorter period.

The occurrence of rainstorms was identified on March 23 and March 27, 2023. The highest number of tweets using the keywords "hujan" (rain) and "badai" (storm) was found on March 25, 2023, with a total of 93 tweets. This was followed by 57 tweets on March 26, 2023, as shown in Figure 3 below. The graph in Figure 3 illustrates an increase in the number of tweets related to rainstorms and hailstorms starting on March 24, 2023, and decreasing on March 27, 2023. The diagram is based on the recorded tweet counts for each day during the research period. Twitter users provided various responses, including real-time reports, complaints, warnings, and hopes, which were recorded as original tweets, replies, and retweets. The diagram was created based on original tweets posted by Twitter users.

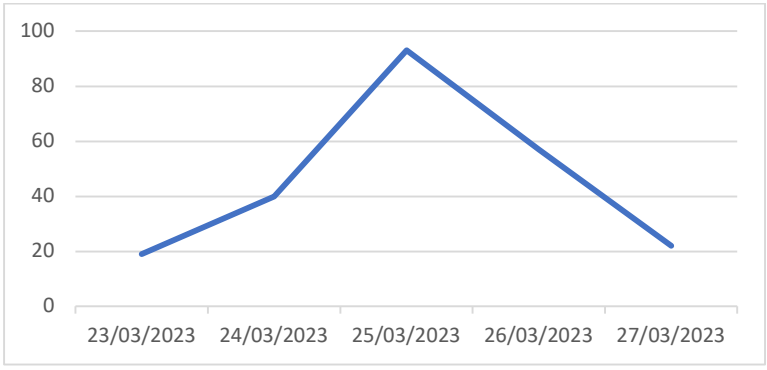

Figure 3. Graph of the Development of the Number of Tweets Over Time.

The abundance of tweets on Twitter regarding rainstorms aligns with the extensive coverage by mass media on the occurrence of extreme weather conditions in various regions of Indonesia. Several mass media outlets report real-time updates on the weather conditions in different areas. Information about extreme weather phenomena affecting several regions in Indonesia is provided by various news portals. Table 1. presents the coverage of

extreme weather conditions that can be accessed online by the general public. Potral news provide insights into early warnings of potential extreme weather in Indonesia, including alerts for heavy rain accompanied by lightning and strong winds.

Table 1. Extreme Weather News in Indonesia from March 23-27, 2023

Media Type	Title	Sources
Republika	West Java Weather Forecast Today March 23, 2023, Heavy Rain in Bandung, Kuningan, Cianjur	(Lukihardianti, 2023)
TribunJogja	BMKG Weather Forecast for Friday, March 24, 2023: Beware of Heavy Rain in 26 Provinces	(Susmayanti, 2023)
Tribunnews	BMKG Early Warning Today, March 25, 2023: Potential Extreme Weather in These 33 Areas	(Widayanti, 2023)
Liputan6	Today's Weather, Saturday, March 25, 2023: Jakarta is Predicted to Have Rain from Afternoon to Tonight	(Flora, 2023)
Liputan6	Today's Weather, Monday, March 27, 2023: Beware of Rain with Thunderstorms in Jabodetabek This Afternoon	(Prastiwi, 2023)
Suarariau	Hailstorm Phenomenon Hits Pekanbaru, BMKG Reveals the Cause	(Faizin, 2023)
tvonenews	Cause of Pekanbaru Being Showered with Hail the Size of Dates on Saturday, March 25, 2023	(Bayu, 2023)
Kompas	Pekanbaru Hit by Hailstorm, Residents Surprised	(Tanjung & Rusiana, 2023)

One of the online news portals, Republika, provides information regarding potential extreme weather warnings in the form of rain that can be accompanied by lightning and strong winds that are localized on March 23, 2023, in parts of West Java. News about extreme weather was also conveyed through the online media portal, namely TribunJogja, reporting that the potential for heavy rain, which could be accompanied by strong winds and lightning, would occur on March 24, 2023, and flush large cities in the regions of Sumatra, Java, Kalimantan, Sulawesi, and Papua. An appeal was also given to residents living at the location of the incident to increase their preparedness for extreme weather. The news portal Tribunnews conveys information about extreme weather warnings sourced from the Meteorology, Climatology, and Geophysics Agency (BMKG) posted on March 25, 2023. Extreme weather is predicted to occur in 33 regions in Indonesia. South Sulawesi is expected to experience rain accompanied by lightning and strong winds, while the other 32 regions in Indonesia will face extreme weather in the form of heavy rain with lightning and strong winds.

Meteorology, Climatology, and Geophysics Agency (BMKG) explained that the potential for extreme weather in 31 provinces is influenced by cyclonic circulation in the waters west of Aceh, west of Bengkulu, and in the Sawu Sea south of West Nusa Tenggara, triggering the formation of convergence zones and slowing down wind speeds. This phenomenon extends from East Nusa Tenggara to the west of Bengkulu and from West Sumatra to Bengkulu (Susmayanti, 2023). Cyclonic circulation observed in several marine areas creates convergence, where winds meet and slow down, in several areas, namely the waters of the Indian Ocean from Aceh to North Sumatra, the southwestern waters of Sumatra to the western Indian Ocean of Sumatra, the South China Sea to North Kalimantan, the North Pacific Ocean from Halmahera to the northern waters of West Papua, the southern coast of Central Java to the southern Indian Ocean of West Nusa Tenggara, and the Arafura Sea to the Aru Sea (Widayanti, 2023).

The phenomenon of heavy rain with high intensity was also reported by the news portal liputan6 on March 25, 2023. Heavy rain accompanied by thunderstorms is predicted to occur in Yogyakarta, Jambi, Bandar Lampung,

and Manado during the daytime, which needs to be anticipated. The potential for rain accompanied by lightning and strong winds also exists in Jakarta, Bogor, Depok, Bekasi, and Karawang. A similar report was also published by the news portal liputan6.com on March 27, 2023. The phenomenon of extreme weather that occurred between March 23-27, 2023, was not limited to heavy rain accompanied by strong winds. Through tweets from Twitter users, the occurrence of hail was also identified in Pekanbaru, Riau. Hail is an extreme weather event characterized by the falling of ice pellets from clouds. The duration of hail is relatively short. Hailstorms accompanied by lightning and strong winds tend to occur more frequently during the transition period from the dry season to the rainy season or vice versa (Djatmiko, 2017). An extreme weather event in the form of hail occurred on March 25, 2023. Several Twitter users located in Pekanbaru, Riau Province, shared real-time updates, warnings, and various responses expressing concerns and complaints about the hailstorm conditions they experienced. This corresponds to the news coverage on various media portals published on March 25, 2023.

Several news articles about the hailstorm were published on various media websites, including the official website of the Riau Provincial Government, tvOnenews.com, and kompas.com. The hailstorm in Pekanbaru City elicited various responses from the public, leading to the dissemination of information about the event through various social media platforms, including Twitter. The official websites of tvonenews and Suarariau uploaded news articles describing the occurrence of heavy rain accompanied by white hailstones the size of dates that hit several areas in Pekanbaru City. The phenomenon was caused by high levels of heating that occurred from morning until afternoon, resulting in the formation of massive clouds.

The media outlet kompas, through its website, also published a similar news article explaining the phenomenon of the hailstorm that occurred in Pekanbaru as a rare and surprising event for the residents. One of the areas affected by the hailstorm was the Tampan District in Pekanbaru. The hailstorm occurred at 5:00 PM local time and lasted for half an hour. The event started with cloudy weather and was followed by rain accompanied by hailstones. This is in line with the indications of hailstorms provided by the Meteorology, Climatology, and Geophysics Agency, which include the hot air experienced a day before the hailstorm, the formation of distinct-edge clouds with a grayish color towering high like cauliflower among cumulus clouds in the morning, the cool air, the rapid swaying of trees, and the sudden occurrence of heavy rain (Djatmiko, 2017).

Distribution of Extreme Weather through Twitter

The extreme weather that occurred during the period of March 23-27, 2023, was identified through tweets by users in various regions of Indonesia. The phenomenon of heavy rain accompanied by lightning, thunder, and strong winds was most detected in the regions of Bandung, Surabaya, Malang, and Jakarta, while the phenomenon of hail occurred in Riau. The locations were recorded when Twitter users posted their tweets and corresponded to the users' locations. The distribution of locations can also be seen in the following Figure 4.

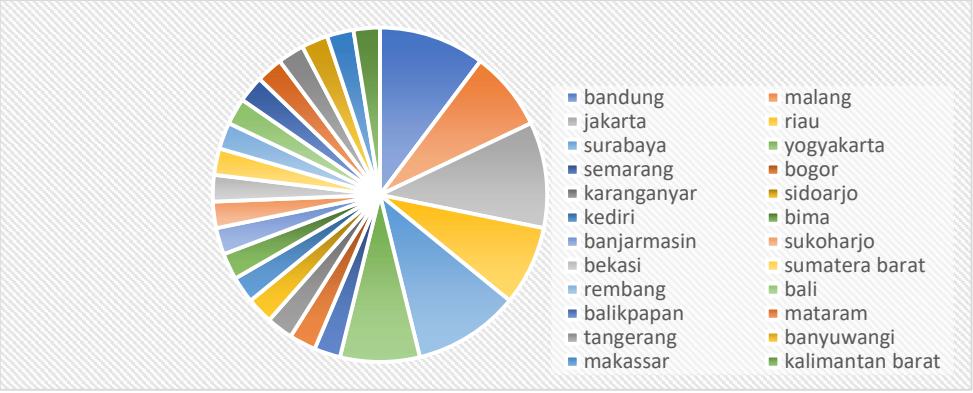

Figure 4. Distribution of Extreme Weather Locations in Indonesia through Twitter.

Figure 4 illustrates the distribution of extreme weather events occurring in various regions across Indonesia, based on the location of users when uploading posts recorded in the Netlytic database. The locations of extreme weather events are also identified through the location information provided by Twitter users within their uploaded posts. The extreme weather that occurred in Indonesia in March 2023 aligns with the predictions made by the Meteorology, Climatology, and Geophysics Agency (BMKG), as published on the media online katadata, tribatanews, CNBC Indonesia, and CNN Indonesia, as seen in Table 2. The public needs to be cautious of the extreme weather during the transitional period between seasons. Strong winds, tornadoes, and heavy rainfall with high intensity are expected to occur from March to May 2023.

Table 2. The News Report on The Prediction of Extreme Weather in Indonesia, March 2023.

MediaType	Title	Sources
Katadata	BMKG Cautions Potential Extreme Weather from March to May 2023	(Nasution, 2023)
Tribatanews	BMKG: Potential Extreme Weather Expected from March to May 2023	(Tribata, 2023)
CNBC Indonesia	BMKG Early Warning: Be Cautious of Extreme Weather in the Next Week	(Emeria, 2023)
CNN Indonesia	BMKG: Beware of the Potential for Extreme Weather in Java and Bali from March - May	(Wicaksono, 2023)

The Meteorology, Climatology, and Geophysics Agency (BMKG) has predicted the dynamic changes in weather due to the influence of the La Niña phenomenon. Below-normal rainfall is expected to occur in several regions such as central Sumatra, central Kalimantan, parts of central Sulawesi, and small parts of Papua. Meanwhile, monthly rainfall categorized as above normal is likely to occur in northern Sumatra and eastern and northern parts of Kalimantan in February and March 2023 (Nasution, 2023).

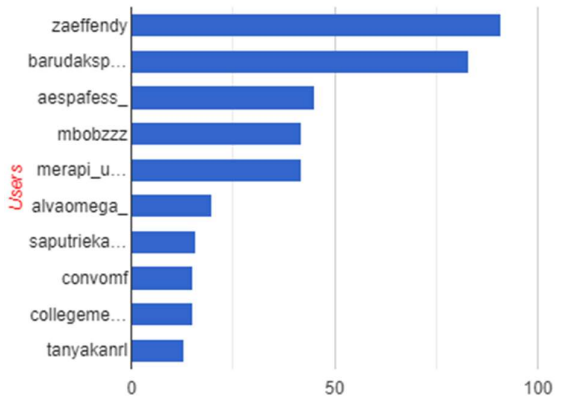

Figure 5. Top Ten Twitter Users Tweeting about Hujan (Rain) and Badai (Storm).

Warnings about extreme weather have been published on the tribatanews.polri.go.id website, stating that several regions in Java Island, Bali, and Nusa Tenggara will experience a transitional period before entering the dry season. The occurrence of extreme weather phenomena should be anticipated, especially in March, April, and May 2023. The increased potential for extreme weather events in Indonesia can trigger various hydro-meteorological disasters such as floods and landslides, posing social and economic risks (Arsjad & Riadi, 2013).

One of the providers of information related to weather and climate anomalies, as well as hydro-meteorological disasters in Indonesia, is the Meteorology, Climatology, and Geophysics Agency (BMKG). Information issued by BMKG can be accessed through various platforms, including their official website and social media accounts. BMKG has an official Twitter account, @infoBMKG, which shares real-time updates on weather and climate conditions in Indonesia. Figure 5 illustrates the list of influential accounts that receive the most retweets from Twitter users. Based on the data, none of the official government information providers rank at the top. Twitter users tend to respond more to information shared by individual accounts, which requires further investigation regarding the validity of the information.

Analysis of Twitter Users Response to Extreme Weather

Predicting extreme weather phenomena is a challenging task. Hydrometeorological disasters create vulnerability in the economy and hinder community activities (Hikmah et al., 2023; Wahyudi et al., 2023). The occurrence of extreme weather phenomena at various locations in Indonesia has elicited various responses from the public, which are shared through tweets. Classifying Twitter users' responses can be grouped into three categories: positive, neutral, and negative. Each response has distinct characteristics identified based on the expressions conveyed through writing.

Positive responses consist of expressions of enthusiasm, hope, and other positive sentiments. Neutral responses contain reports of events, warnings, and information related to extreme weather phenomena, including storms and hailstorms. Negative responses include complaints, expressions of sadness, fear, worries, and other negative expressions. Public concerns regarding the information on hydrometeorological disasters can be observed from the high percentage of individuals seeking early weather warnings. This indicates the level of public vigilance toward hydrometeorological disasters (Saragih et al., 2021).

Based on the data collected from March 23 to 27th, 2023, there were 249 responses given through tweets regarding the occurrence of extreme weather. Figure 6 illustrates the percentage of Twitter users' responses. It is noted that most Twitter users provided negative responses to the phenomena of storms and hailstorms that occurred in several areas of Indonesia. The negative responses expressed complaints, anger, concerns, and fears about the resulting impacts. The grievances shared by the public were related to damages to public facilities, housing, and the difficulty of mobility during extreme weather conditions.

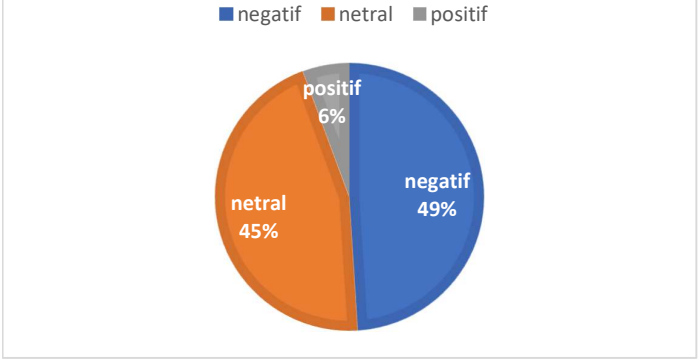

Figure 6. Twitter User Response Percentage

Around 45% of Twitter users provided neutral responses, informing about the current conditions, including natural phenomena experienced such as strong winds, cold temperatures, heavy rain, and environmental damages such as fallen trees in their respective areas affected by extreme weather. Additionally, Twitter users

also issued warnings to be more cautious about slippery roads to prevent accidents. Neutral responses were also conveyed by official accounts of authorized institutions that provide disaster warnings, such as BMKG (Meteorology, Climatology, and Geophysics Agency) and local governments. Positive responses from the community accounted for only 6% of the total tweet data. This indicates that the extreme weather is perceived as having detrimental effects on the community, causing discomfort.

Social media, especially Twitter, enables effective crisis responses and can be utilized to enhance crisis management capabilities by considering expert assessments, stakeholder perspectives, and crowdsourced opinions (Chan, 2013). Social media platforms are increasingly important for individuals responding to emergencies, as they offer a platform to seek help and respond to assistance requests. Analyzing behavioral patterns within these networks can improve community-level disaster response initiatives. Those affected by disasters often turn to social media for immediate aid, whether it's for debris cleanup, supplies delivery, or emergency rescue. Fellow social media users connected within the network can assist by sharing the requests or offering direct help (DiCarlo & Berglund, 2021).

Discussion

Information about extreme weather can be accessed through various media portals, both online through websites, social media, and print media. The reliability of information sources needs to be considered and monitored. Freely distributed information, especially on social media platforms like Twitter, can consist of both valid and false news or hoaxes. The prevalence of climate-related hoaxes has been found to be dominant (Jang & Hart, 2015). Hoaxes cause doubt and panic regarding the received information (Juditha, 2020). Misinformation and hoaxes are situational factors of societal vulnerability that influence how people access, comprehend, and respond to information about hazards (Hansson et al., 2020). If the public tends to believe risk information from various sources without validation, the risk of societal vulnerability becomes high. Disaster risk information provided by individuals lacking competence from different sources can disrupt conventional risk communication and diminish the effectiveness of legitimate risk communication during community disaster interventions (Norman et al., 2012). The case study of the spread of hoaxes during the eruption of Mount Agung caused a significant portion of the population to feel threatened despite not residing in the disaster zone of Mount Agung. Thus, the anxiety and insecurity they experienced were largely due to the abundance of information about Mount Agung circulating on their social media platforms. This situation was exacerbated by the rapid dissemination of unverified information about Mount Agung on social media (Gelgel, 2020).

Research on the role of social media in identifying extreme weather has been conducted to understand the information (Purwandari et al., 2021; Effrosynidis et al., 2022), opinions, and experiences of the community when facing such phenomena in the context of social-political efforts (Roxburgh et al., 2019), not for disaster mitigation. Information about disaster events can serve as a form of disaster mitigation in the pre-disaster phase to increase public awareness and preparedness, thus the sources of disaster-related information must be accountable. Research conducted by Vishwanath et al., (2023) shows that social media, especially Twitter, plays a role in disaster management. It is a process of minimizing the impact of disasters. Social media generates a lot of information that can be used to provide real-time news to disaster relief organizations. Social media users play an important role in disseminating disaster information. User posts on social media show emotions as a response to the experienced disaster. The implications can be used to enhance the region's adaptability to disasters and establish resilient disaster-prone areas (Li et al., 2023; Chen et al., 2022).

Tweets uploaded by the public can serve as a form of mitigation to anticipate losses caused by extreme weather conditions. The provided information related to warnings can increase public vigilance, enabling them to be more cautious in choosing travel routes. Complaints expressed by the public can be used as evaluation material for local

governments to formulate appropriate policy strategies in dealing with extreme weather conditions in the future. Additionally, they can be used as reference sources to identify issues that arise, such as repairing public facilities damaged by extreme weather. The role of social media in disaster management is still limited to the pre-disaster phase, but in-depth studies are still needed in the disaster recovery phase (Ogie et al., 2022).

Integrating social media into community preparedness activities for emergency situations can aid in building social capital and community resilience. This facilitates both professional responders and ordinary citizens in utilizing familiar social networks and social media tools during emergency conditions (Findayani, 2020). As exemplified in the research conducted by Shoyama et al., (2021), integrating social media data with hazard monitoring information can facilitate the development of decision-based early warning systems for flood disasters. The combination of natural disaster monitoring and social media data can enhance warning systems, raising awareness among disaster managers and citizens about emergency events.

Social media is becoming increasingly important as a source and dissemination platform for information during natural disasters. The abundant data from social media users can be analyzed to comprehend the situation, impacts, and public sentiments during disasters. Individuals who are well-prepared for emergencies are more likely to use social media during natural disasters compared to those who rely on decisions made by local authorities (Zander et al., 2022). In the case study of the 2017 eruption of Mount Agung, Twitter proved to enhance the distribution of disaster information, particularly in disseminating news and disaster documentation (Widayanti, 2023).

Conclusions

The phenomenon of extreme weather in Indonesia during the period of March 23-27, 2023, has drawn the attention of many people, especially social media users like Twitter. Severe storms were identified on March 23 and 27, 2023. There was also the phenomenon of hail in Pekanbaru, Riau. Mass media outlets such as Tribunnews.com and Liputan6.com provided coverage on early warnings of potential extreme weather in Indonesia, including warnings of heavy rain accompanied by thunder and strong winds. The news portal Tribunnews.com conveyed information about the extreme weather warning from the Meteorology, Climatology, and Geophysics Agency, which was posted on March 25, 2023. A similar report was also published by the news portal Liputan6.com on March 27, 2023.

During the period of March 23-27, 2023, extreme weather conditions such as heavy rain accompanied by lightning, thunder, and strong winds occurred in several regions of Indonesia, with the highest occurrences reported in Bandung, Surabaya, Malang, and Jakarta, as well as hail in Riau. The Meteorology, Climatology, and Geophysics Agency has predicted the occurrence of extreme weather during the seasonal transition period from March to May 2023, which can trigger various hydrometeorological disasters such as floods and landslides. It is important for the public to be cautious of extreme weather and to rely on credible sources of information.

Most Twitter users' responses were negative (49%), followed by neutral responses (45%), and positive responses (6%). Tweets posted by the public can serve as a form of mitigation to anticipate the risks and losses caused by extreme weather conditions. They can also be used as a reference to identify existing issues and formulate appropriate policy strategies to address extreme weather events in the future.

References

Agatha, F., Nurhakim, I., & Bayuardi, G. (2022). Kewas*pada*an Masyarakat terhadap Bencana Banjir Akibat Potensi Cuaca yang Ekstrem. Jurnal Pendidikan Geografi dan Pariwisata. 2(2), 14-29.

Anggreni, L. S., Nugroho, R. A., Luthfi, H. S., Kresna, I. M., & Santoso, T. B. (2019). Penggunaan kata umpatan di Twitter berdasarkan gender di pilkada Sumatera Utara 2018. *Jurnal Kajian Komunikasi*, *7*(1), 121.

https://doi.org/10.24198/jkk.v7i1.18447

Arsjad, S, Riadi, B. (2013). Potensi Resiko Bencana Alam Longsor (Potential Risk of Landslide Related to Extreme Weather in Ciamis Region, West Java). *Jurnal Ilmiah Geomatika*, *19*(1), 57–63.

Bayu, E. (2023, March 25). *Penyebab Pekan Baru Diguyur Hujan Es Sebesar Biji Kurma Sabtu 25 Maret 2023*. Tvonenews. https://www.tvonenews.com/daerah/sumatera/110148-penyebab-pekanbaru-diguyur-hujan-es-sebesar-biji-kurma-sabtu-25-Maret-2023

Caraka, Rezzy Eko. Yasin, H. suparti. (2015). Jurnal Meteorologi Klimatologi dan Geofisika. *Bmkg*, *2*(2), 1–16.

Chan, J. C. (2013). the Role of Social Media in Crisis Preparedness, Response and Recovery. *Rahs Think Centre*, 1–14. http://www.oecd.org/governance/risk/The role of Social media in crisis preparedness, response and recovery.pdf

Chatfield, A. T., & Brajawidagda, U. (2012). Twitter tsunami early warning network: A social network analysis of twitter information flows. *ACIS 2012 : Proceedings of the 23rd Australasian Conference on Information Systems*.

Chen, Y., He, S., & Zhou, Z. (2022). Investigation of social media representation bias in disasters: Towards a systematic framework. *International Journal of Disaster Risk Reduction*, *81*, 103312. https://doi.org/10.1016/J.IJDRR.2022.103312

DiCarlo, M. F., & Berglund, E. Z. (2021). Connected communities improve hazard response: An agent-based model of social media behaviors during hurricanes. *Sustainable Cities and Society*, *69*(June 2020), 102836. https://doi.org/10.1016/j.scs.2021.102836

Djatmiko, H. T. (2017). *Penjelasan Singkat Fenomena Hujan Es*. BMKG. https://www.bmkg.go.id/info-aktual/?p=penjelasan-singkat-hujan-es&tag=info-aktual&lang=ID

Effrosynidis, D., Karasakalidis, A. I., Sylaios, G., & Arampatzis, A. (2022). The climate change Twitter dataset. *Expert Systems with Applications*, *204*, 117541. https://doi.org/10.1016/J.ESWA.2022.117541

Emeria, D. C. (2023). *Peringatan Dini BMKG, Waspada Cuaca Ekstrem Sepekan ke Depan*. CNBN Indonesia. https://www.cnbcindonesia.com/news/20230315003132-4-421696/peringatan-dini-bmkg-waspada-cuaca-ekstrem-sepekan-ke-depan

Faizin, E. (2023, March 26). *fenomena Hujan Es Guyur Pekanbaru, BMKG Ungkap Penyebabnya*. Suarariau. https://riau.suara.com/read/2023/03/26/043823/fenomena-hujan-es-guyur-pekanbaru-bmkg-ungkap-penyebabnya

Findayani, A. (2020). Peran Sosial Media dalam Penyampaian Informasi dan Kesiapsiagaan Masyarakat Menghadapi Covid-19 di Kota Semarang. *Jurnal Geografi : Media Informasi Pengembangan Dan Profesi Kegeografian*, *17*(2), 63–69. https://doi.org/10.15294/jg.v17i2.24506

Flora, M. (2023, March 25). *Cuaca Hari Ini Sabtu 25 Maret 2023: Jakarta Diprediksi Hujan Siang hingga Malam Nanti*. Liputan6. https://www.liputan6.com/news/read/5242488/cuaca-hari-ini-sabtu-25-maret-2023-jakarta-diprediksi-hujan-siang-hingga-malam-nanti

Gelgel, N. M. R. A. (2020). Media Sosial Dan Literasi Kebencanaan Di Bali. *Interaksi: Jurnal Ilmu Komunikasi*, *9*(1), 19–30. https://doi.org/10.14710/interaksi.9.1.19-30

Gruzd, A., & Mai, P. (2023). *About Netlytic*. Netlytic. https://netlytic.org/home/?page_id=10834

Gruzd, A., Paulin, D., & Haythornthwaite, C. (2016). Analyzing Social Media And Learning Through Content And Social Network Analysis: A Faceted Methodological Approach. *Journal of Learning Analytics*, *3*(3), 46–71. https://doi.org/10.18608/jla.2016.33.4

Hansson, S., Orru, K., Siibak, A., Bäck, A., Krüger, M., Gabel, F., & Morsut, C. (2020). Communication-related vulnerability to disasters: A heuristic framework. *International Journal of Disaster Risk Reduction*, *51*. https://doi.org/10.1016/j.ijdrr.2020.101931

Haryoko, U., & Gunawan, D. (2022). Analisis Hujan Agustus 2022. *Buletin Informasi Iklim September*, *9*, 1–7.

Hernandez-Suarez, A., Sanchez-Perez, G., Toscano-Medina, K., Perez-Meana, H., Portillo-Portillo, J., Sanchez, V., & Villalba, L. J. G. (2019). Using twitter data to monitor natural disaster social dynamics: A recurrent neural network approach with word embeddings and kernel density estimation. *Sensors (Switzerland)*, *19*(7).

https://doi.org/10.3390/s19071746

Hikmah, H., Asrirawan, A., Apriyanto, A., & Nilawati, N. (2023). Peramalan Data Cuaca Ekstrim Indonesia Menggunakan Model ARIMA dan Recurrent Neural Network. *Jambura Journal of Mathematics*, *5*(1), 230–242. https://doi.org/10.34312/jjom.v5i1.17496

Huang, W. (2022). Dean Lusher, Johan Koskinen, Garry Robins. Exponential Random Graph Models for Social Networks: Theory, Methods, and Applications. New York: Cambridge University Press, 2012. 360 pp, $36.99 (pbk), ISBN: 9780521141383. *Quality & Quantity*, *56*(3), 1367–1370. https://doi.org/10.1007/s11135-021-01180-0

Jang, S. M., & Hart, P. S. (2015). Polarized frames on "climate change" and "global warming" across countries and states: Evidence from Twitter big data. *Global Environmental Change*, *32*, 11–17. https://doi.org/10.1016/j.gloenvcha.2015.02.010

Juditha, C. (2020). People Behavior Related To The Spread Of Covid-19's Hoax. *Journal Pekommas*, *5*(2), 105. https://doi.org/10.30818/jpkm.2020.2050201

Kemp, S. (2021). *Digital 2021: Indonesia*. Datareportal. https://datareportal.com/reports/digital-2021-indonesia

Kim, J., & Hastak, M. (2018). Social network analysis: Characteristics of online social networks after a disaster. *International Journal of Information Management*, *38*(1), 86–96. https://doi.org/10.1016/j.ijinfomgt.2017.08.003

Lestari, P., Ramadhaniyanto, B., & Wardyaningrum, D. (2018). Pemberitaan di Media Online untuk Pengurangan Risiko Bencana Gunung Sinabung. *Jurnal Kajian Komunikasi*, *6*(1), 106. https://doi.org/10.24198/jkk.v6i1.15168

Li, L., Du, Y., Ma, S., Ma, X., Zheng, Y., & Han, X. (2023). Environmental disaster and public rescue: A social media perspective. *Environmental Impact Assessment Review*, *100*, 107093. https://doi.org/10.1016/J.EIAR.2023.107093

Lukihardianti, A. (2023, March 23). *Perkiraan Cuaca Jabar Hari Ini 23 Maret 2023, Hujan Lebat di Bandung, Kuningan, Cianjur*. Republika. https://bandung24jam.republika.co.id/posts/207084/prakiraan-cuaca-jabar-hari-ini-23-maret-2023-hujan-lebat-di-bandung-kuningan-cianjur

Mananohas, M. A., Bobanto, M. D., & Ferdy, F. (2019). Hubungan Cuaca dan Tanaman Pangan Menggunakan Regresi Linear di Kota Tondano. *D'CARTESIAN*, *8*(2), 169. https://doi.org/10.35799/dc.8.2.2019.24390

Muzaki, N. H. (2021). Analisis Kondisi Atmosfer Saat Kejadian Hujan Lebat dan Angin Kencang di Probolinggo Berdasarkan Citra Satelit dan Citra Radar. *Jurnal Ilmu Dan Inovasi Fisika*, *5*(2), 142–156. https://doi.org/10.24198/jiif.v5i2.31333

Nasution, A. D. (2023, January 27). *BMKG Waspadai Potensi Cuaca Ekstrem pada Maret hingga Mei 2023*. Katadata. https://katadata.co.id/ameidyonasution/berita/63d3b24668ad5/bmkg-waspadai-potensi-cuaca-ekstrem-pada-Maret-hingga-mei-2023

Norman, I. D., Aikins, M., & Binka, F. (2012). Earthquake hoax in Ghana: Exploration of the cry wolf hypothesis. *Journal of Public Health in Africa*, *3*(1), 52–58. https://doi.org/10.4081/jphia.2012.e14

Nugroho, H. D. (2019). Analisis daerah rawan bencana banjir di kecamatan kebumen kabupaten kebumen jawa tengah. *Seminar Nasional Penginderaan Jauh Ke-6 Tahun 2019*, 237.

Ogie, R. I., James, S., Moore, A., Dilworth, T., Amirghasemi, M., & Whittaker, J. (2022). Social media use in disaster recovery: A systematic literature review. *International Journal of Disaster Risk Reduction*, *70*(August 2021), 102783. https://doi.org/10.1016/j.ijdrr.2022.102783

Prasetyaningtyas, K. (2023). *Analisis Dinamika Atmosfer Dasarian III Maret 2023*. BMKG. https://www.bmkg.go.id/iklim/dinamika-atmosfir.bmkg

Prasetyo, S., Hidayat, U., Haryanto, Y. D., & Riama, N. F. (2021). Variasi dan Trend Suhu Udara Permukaan di Pulau Jawa Tahun 1990-2019. *Jurnal Geografi : Media Media Informasi Pengembangan Dan Profesi Kegeografian*, *18*(1), 60–68. https://doi.org/10.15294/jg.v18i1.27622

Prastiwi, D. (2023, March 27). *Cuaca Hari Ini Senin 27 Marett 2023, Waspada Hujan Disertai Petir di Jabodetabek Siang Nanti*. Liputan6. https://www.liputan6.com/news/read/5243771/cuaca-hari-ini-senin-27-maret-

2023-waspada-hujan-disertai-petir-di-jabodetabek-siang-nanti

Purwandari, K., Sigalingging, J. W. C., Cenggoro, T. W., & Pardamean, B. (2021). Multi-class Weather Forecasting from Twitter Using Machine Learning Aprroaches. *Procedia Computer Science*, *179*(2019), 47–54. https://doi.org/10.1016/j.procs.2020.12.006

Riyanto, A. D. (2021). *Hootsuite (We are Social). Indonesian Digital Report 2021*. Hootsuite. https://andi.link/hootsuite-we-are-social-indonesian-digital-report-2021/

Rohmah, K. (2023). *Bappenas Diseminasikan Data Statistik Kebencanaan*. Bappenas. https://diskominfo.kaltimprov.go.id/kebencanaan/bappenas-diseminasikan-data-statistik-kebencanaan

Roxburgh, N., Guan, D., Shin, K. J., Rand, W., Managi, S., Lovelace, R., & Meng, J. (2019). Characterising climate change discourse on social media during extreme weather events. *Global Environmental Change*, *54*(November 2018), 50–60. https://doi.org/10.1016/j.gloenvcha.2018.11.004

Rudianto. (2015). Komunikasi dalam Penanggulangan Bencana. *Jurnal Simbolika*, *1*(1), 51–61.

Saragih, I. J. A., Sirait, M., & Sari, D. A. (2021). Deskripsi Opini Publik tentang Bencana Alam untuk Rencana Studi Mitigasi di Indonesia (Studi kasus: Bencana Hidrometeorologi). *MKGI: Jurnal Meteorologi, Klimatologi Geofisika Dan Instrumentasi*, *1*(1), 33–39.

Senova, A. (2016). Literasi Media sebagai Strategi Komunikasi Tim Sukses Relawan Pemenangan Pemilihan Presiden Jokowi JK di Bandung. *Jurnal Kajian Komunikasi*, *2*, 142–153.

Setiamukti, M. F., & Nasvian, M. (2023). Social Network Analysis #Usuttuntas Pada Media Sosial Twitter (Data Twitter 11 November 2022). *Ekspresi Dan Persepsi : Jurnal Ilmu Komunikasi*, *6*(1), 124–137. https://doi.org/10.33822/jep.v6i1.5427

Setiawan, D. (2021). Analisis Curah Hujan di Indonesia untuk Memetakan Daerah Potensi Banjir dan Tanah Longsor dengan Metode Cluster Fuzzy C-Means dan Singular Value Decompotition (SVD). *Engineering, MAthematics and Computer Science (EMACS) Journal*, *3*(3), 115–120. https://doi.org/10.21512/emacsjournal.v3i3.7428

Shoyama, K., Cui, Q., Hanashima, M., Sano, H., & Usuda, Y. (2021). Emergency flood detection using multiple information sources: Integrated analysis of natural hazard monitoring and social media data. *Science of the Total Environment*, *767*, 144371. https://doi.org/10.1016/j.scitotenv.2020.144371

Susmayanti, H. (2023, March 24). *Prakiraan Cuaca BMKG Jumat 24 Maret 2023, Waspadai Hujan Lebat di 26 Provinsi*. TribunJogja. https://jogja.tribunnews.com/2023/03/24/prakiraan-cuaca-bmkg-jumat-24-maret-2023-waspadai-hujan-lebat-di-26-provinsi

Tanjung, I., & Rusiana, D. A. (2023, March 25). *Pekanbaru Dilanda Hujan Es, Warga Terkejut*. https://regional.kompas.com/read/2023/03/25/195649578/pekanbaru-dilanda-hujan-es-warga-terkejut?page=all

Tribata. (2023, January 27). *BMKG: Cuaca Ekstrem Potensi Terjadi di Maret-Mei 2023*. https://tribratanews.polri.go.id/blog/nasional-3/bmkg-cuaca-ekstrem-potensi-terjadi-di-Maret-mei-2023-53822

Vishwanath, T., Shirwaikar, R. D., Jaiswal, W. M., & Yashaswini, M. (2023). Social media data extraction for disaster management aid using deep learning techniques. *Remote Sensing Applications: Society and Environment*, *30*, 100961. https://doi.org/10.1016/J.RSASE.2023.100961

Wahyudi, M., Rahman, A. A., & Rizal, M. (2023). Respon Nelayan terhadap Fenomena Iklim (Perspektif Sosial Ekonomi). *Journal on Education*, *05*(04), 16748–16758.

Wicaksono, A. (2023). *BMKG: Waspada Potensi Cuaca Ekstrem di Jawa dan Bali Maret-Mei*. CNN Indonesia. https://www.cnnindonesia.com/nasional/20230127085833-20-905480/bmkg-waspada-potensi-cuaca-ekstrem-di-jawa-dan-bali-maret-mei

Widayanti, O. W. (2023, March 25). Peringatan Dini BMKG Hari Ini, 25 Maret 2023: Potensi Cuaca Ekstrem Terjadi di 33 Wilayah Ini. *Tribunnews*. https://www.tribunnews.com/nasional/2023/03/25/peringatan-dini-bmkg-hari-ini-25-Maret-2023-potensi-cuaca-ekstrem-terjadi-di-33-wilayah-ini?page=3

Wirjohamidjojo, S., & Swarinoto, Y. (2010). Iklim Kawasan Indonesia (Dari Aspek Dinamik - Sinoptik). In *Badan Meteorologi Klimatologi dan Geofisika*.

Zander, K. K., Sibarani, R., Lassa, J., Nguyen, D., & Dimmock, A. (2022). How do Australians use social media during natural hazards? A survey. *International Journal of Disaster Risk Reduction*, *81*(July), 103207. https://doi.org/10.1016/j.ijdrr.2022.103207