Community-based flood and landslides disaster management for mitigation of road networks performance with Technology Digital: A Qualitative Study

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Abstract

Natural disasters in the form of floods and erosion in remote area road networks pose challenges for the government. The involvement of community-based disaster management can make it easier for stakeholders to carry out disaster mitigation intelligently. Digital technology can be used to provide information about disaster conditions and facilitate coordination between related parties in the management of floods and landslides The purpose of this research is to explore the cultural understanding of the local Community so that it can encourage community-based involvement in optimizing road infrastructure services that have been disrupted due to floods and landslides. This research method is qualitative research using data from focus group discussions, surveys, and depth interviews. Several community leaders, non-government organizations, and the government became sources of data and discussions. The research results are divided into four main results, 1) the Community in the road network area has understood the causes and triggers of flood and landslide disasters that can disrupt road functions; 2) the Community is willing and actively involved in disaster preparedness; 3) Community can be an essential part in the mitigation process, starting from pre, during, and after the disaster; 4) Social media platforms have optimal functions to accelerate community communication in mitigating and handling flood and landslide disasters.

Community-based;
Disaster management;
Flood and landslides;
Road networks;

INTRODUCTION

Natural disasters in Indonesia occur pretty often. In 2022 alone, there were 1257 floods, 931 tornadoes, 566 landslides, 250 forest fires, 22 earthquakes, 22 tidal waves, and four droughts.[1] The natural disaster has caused various risks of human loss, such as evacuating 3,781,976 people, injuring 831 people, dying 195 people, and missing as many as 28 people. In addition, the most visible damage to infrastructure is in the form of 7765,967 submerged buildings, 270 damaged bridges, 519 educational facilities, 320 worship facilities, 76 health facilities, and various other infrastructures. The various impacts of disasters must be mitigated and handled quickly so that government services can continue to run correctly. Digital technology can be used in disaster management to provide information, facilitate communication, and optimize early action, including: internet, web-based Geographic Information System (GIS), Indonesia Network for Disaster Information (INDI). The use of digital technology can help strengthen preparedness and reduce disaster risk. Therefore, the development of technology and innovation coupled with the use and adoption of disaster values is very important to improve disaster management capabilities in Indonesia[2]. The problem is that community-

based flood and landslide disaster management is an approach [3] that involves active community participation in disaster mitigation and response efforts [4]. Integrating digital technology in disaster management has several benefits and solves several related problems so that monitoring and early warning and mapping and analysis are needed [5] [6].

This is important to discuss because Floods and landslides can cause damage to facilities and infrastructure including the road network, so that it can disrupt the performance of the road network. [7] Floods and landslides disasters can cause people to lose facilities and infrastructure, including road networks, so that they can disrupt community activities. In landslide disaster mitigation, it is necessary to conduct research to find out the description of the implementation of landslide disaster mitigation in an area. In flood and soil disaster mitigation landslides, it is necessary to conduct research to find solutions for landslide and flood disaster mitigation based on the local wisdom of the village community.

This is a problem because community-based flood and landslide disaster management using digital technology is important [8] [9] [10] and necessary because there are a number of problems that need to be addressed, including the complexity and breadth of the scale of the disaster, limited resources and local knowledge among people living in vulnerable areas who have the knowledge valuable information about disaster patterns, alternative evacuation routes, or traditional practices in disaster mitigation. Research on community-based flood and landslide disaster management to mitigate road network performance was conducted to identify problems and find solutions in flood and landslide disaster management that can help mitigate road network performance. Some of the reasons this research was conducted include To find out the description of the implementation of landslide disaster mitigation in an area [11], To assist the parties in mitigating the frequent occurrence of floods and landslide and To find solutions for mitigating landslides and floods based on the local wisdom of the village community.

The problem to be solved so that community-based flood and landslide disaster management is needed to mitigate road network performance with digital technology is related to road network performance mitigation, namely monitoring road network performance [12]. To overcome the problem of community-based flood and landslide disaster management in mitigating the performance of the road network with digital technology, namely providing public awareness and education and forming volunteer groups. Through collaboration between the community, government and other related parties, as well as the use of digital technology, flood and landslide disaster management can be more effective in mitigating the performance of the road network [13] [14] [15].

This research was conducted to mitigate the performance of the road network with digital technology for reasons of increasing the effectiveness of mitigation, reducing risks and losses and increasing understanding of the interaction between technology and disaster management so that solutions and recommendations can be found that can be applied in the management of floods and landslides based on community to improve the performance of the road network in the face of disasters. In community-based flood and landslide disaster management to mitigate road network performance with digital technology, there are several innovations that can be proposed, including sensor-based early warning systems, risk mapping with high-level mapping technology and mobile applications for disaster reporting. Some of the actions that can be taken include data collection and analysis, early warning and communication as well as community involvement in training and education. So that by integrating digital technology in community-based disaster management, road network performance can be improved through accurate monitoring, mapping of vulnerable areas, effective communication, and better data collection. By adopting a community-based approach with digital technology, these problems can be tackled more effectively. Through accurate monitoring, proper risk mapping, good communication, and monitoring road network performance, mitigation efforts can be improved, and road network performance can be improved in the face of floods and landslides [16] [17].

The state is responsible for handling the impact of disasters and ensuring that the Community can carry out its activities safely. Handling the impact of disasters that must receive attention, among others, is maintaining the connectivity of the road and bridge network. In addition, it must provide clean water and drinking water facilities, ensuring the availability of sanitation and temporary shelter. Next is to relocate affected victims and coordinate with related parties to ensure the handling of infrastructure damage. Indonesia is an archipelagic country with a tropical climate, so it has a significant risk of weather changes. By conducting this research, it is hoped that appropriate solutions can be found in the

management of community-based floods and landslides to help mitigate the performance of the road network, To optimize the handling of natural disasters, especially floods and landslides, it is necessary to increase community capacity building. Community-based capabilities can be optimized through disaster-safe education unit programs and disaster-resilient community programs.

METHOD

The discussion in this paper focuses on communities along the road network in the districts of Sidrap, Enrekang, Tana Toraja, North Toraja, Palopo, and Luwu of South Celebes Province-Indonesia. Details of the location can be seen in figure 3. The road network in this area is mainly surrounded by the Latimojong of Celebes mountains, which are young, have unstable geology, steep slopes, and unpredictable climate. Due to meteorological, geographical, and geological conditions and socio-economic characteristics, some areas are vulnerable to flood and landslide disasters. Therefore, this study selected three central communities in the area.

CSV data, type Analysis, by creating a map based on text data, then reading data from bibliographic data, then selecting the Scopus CSV database, then choosing fields whose fields from which terms will be extacted, namely title and abstract fields with a full counting method., in selecting the minimum threshold number of occurrences of a term 5 then of the 2612 terms, 104 meets the threshold then the number terms to be selected is 62.

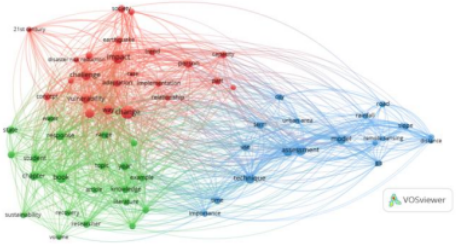

Figure 1. Network Analysis CSV Data

This CSV Network Analysis can assist in community-based flood and landslide disaster management to mitigate road network performance [17][18]. In this analysis using the VOS Viewer, users can take advantage of this feature to visualize and analyze data networks related to certain research topics. The benefits of Network Analysis CSV Data in VOS Viewer in community-based flood and landslide disaster management for mitigating road network performance, namely Facilitating users in visualizing and analyzing bibliometric networks related to certain research topics, so that they can assist in understanding research trends and developments of certain topics in the field studied.

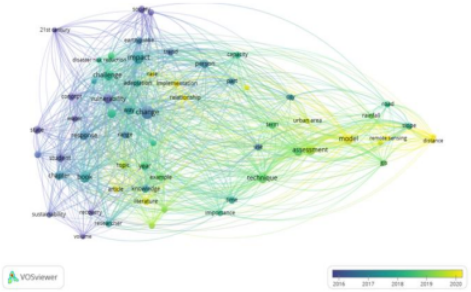

Figure 2. Overlay Analysis CSV Data

Overlay Analysis CSV Data in VOS Viewer is a technique that can be used to map flood and landslide prone areas in geospatial analysis. Some of the information that can be retrieved from search results VOS Viewer is a software tool for analysis that can be used to visualize and analyze data networks related to certain research topics and VOS Viewer can be used to visualize and analyze data more effectively and efficiently, and can assist in identify research trends and developments on specific topics in the field of community-based flood and landslide disaster management for mitigating road network performance.

By using the CSV metadata from Scopus, this Scopus CSV file contains information such as article title, author name, journal or book name, volume and page number, year of publication, and DOI (Digital Object Identifier) number or URL. The information will be used to carry out bibliometric analysis, monitor the performance of scientific publications, and create research reports and by using the Scopus CSV file, users can access and analyze bibliographical data and metadata from thousands of scientific publications indexed on Scopus, facilitating research and analysis in the field of science. and technology. Scopus CSV file imported into VOS Viewer to help analyze scientific networks and map collaboration between researchers or institutions in a research field. By using a Scopus CSV file in the VOS Viewer, users can create collaborative networks based on author co-authority, keywords, and the journal or book where the article was published. And the use of Scopus CSV files in the VOS Viewer can assist scientific network analysis and map collaboration between researchers or institutions, make it easier

for users to understand patterns of collaboration and developments in certain research fields, and assist decision making in research and development of science and technology.

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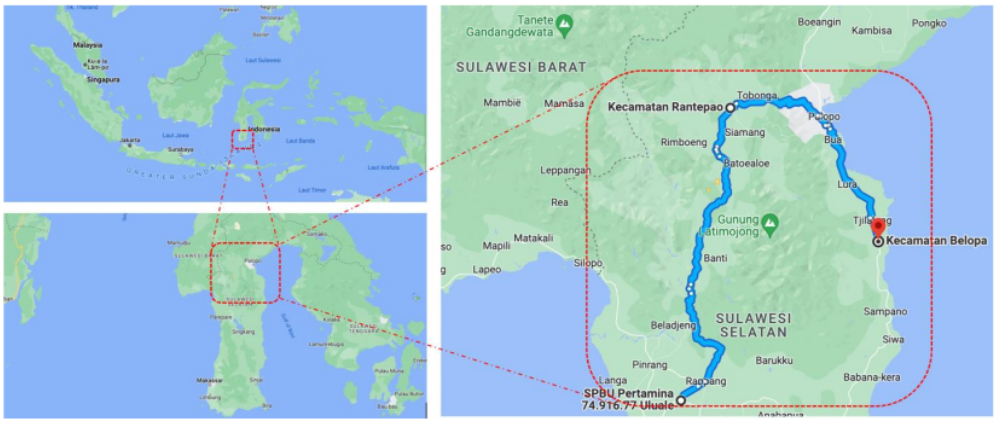

Figure 3. Case Study Area

This study considers various aspects during case study selection. This assumes that the Community has adapted to the flood and slide disaster [19].[20] The selection of the road network considers several essential things. First, the road network has a record of frequent flood and landslide disasters, but for hundreds of years, the road network has served the Community in the area. Second, it can adapt based on local wisdom identified in the Community along the road network. Therefore, this study assumes that the communities along the road network have adapted sustainably to flood and landslide disasters.

Data collection and analysis were carried out through group discussion forums [20](FGD), depth interviews [21], and field surveys [22] at flood and landslide disaster locations. FGDs were held in 3 central locations, namely Palopo, Rantepao, and Enrekang, in October 2022. FGD participants included the national government, local government, contractors, consultants, local communities, and non-government organizations (NGOs). As in other qualitative studies, the researcher must approach the area and its people. Therefore, two field visits were carried out in this study; and a preliminary field survey was conducted in early and late October 2022.

Documentation of FGD activities, surveys, and depth interviews can be seen in figure 4.

Figure 4. FGD, Survey, and Depth-Interview

FGDs are used to collect as much data as possible from participants. Depth interviews were conducted to obtain data from individual informants, while the information obtained from FGDs was information, attitudes, opinions, and community decisions. Digital technology can be used to facilitate research and identification of types of natural disasters that often cause damage to irrigation networks, including road networks.

Figure 5. Digital Monitoring Community-Based Flood and Landslide Disaster Management [23]

Digital monitoring can assist in managing community-based floods and landslides to mitigate road network performance and improve the monitoring function in achieving performance and accelerating flood control. Thus the truth of information is no longer subjective but becomes intersubjective. Because during the discussion, each participant paid attention to his own opinion and considered what other FGD participants said.

RESULTS AND DISCUSSION

The research results through FGD, dept interview, and survey resulted in two main things. First, the flood and landslide disaster mitigation approaches based on Community on the road network. The second is the factors that influence the success of flood and landslide disaster management in a community-based road network. The former comprised three phases: pre-disaster, during disaster, and post-disaster. The preparation of the mitigation program needs to be supported by data and information regarding regional conditions and the local Community's characteristics. The availability of appropriate data and information is expected to maximize the use of local resources, including labor, materials, and organization. One method that can be used to explore the Community's understanding and perception of flood and landslides disaster on the road network is using the FGD method. This qualitative data collection technique has produced several issues. This technique is intended to obtain data from the Community based on the results of discussions that focus on a particular problem.

Community-based flood disaster management approaches for road network area

The FGD with the Community results explained that a flood disaster is a seasonal threat that occurs when a body of water overflows from an existing channel and inundates the surrounding area. Floods are the most common natural threat and are detrimental in terms of humanity and the economy. Ninety percent of natural disasters are related to floods. Types of flooding often occur: immediate floods or delivery and influenced by tides for low-lying areas.

According to the survey results, the causes of flood disasters are primarily due to long-term rain or heavy daily rainfall. Next is the result of soil erosion which leaves rocks that causes rainwater to flow over the ground without infiltration. In addition, there is poor handling of waste that clogs waterways so that bodies of water overflow and flood the surrounding area. The phenomenon in the road network of the case study location shows that the construction of residential areas, namely vacant land, is converted into a house or place of business which causes loss of rainwater absorption. The construction of residential areas can increase the risk of flooding up to 6 times compared to open land, which usually has a high water absorption capacity. This problem often

occurs in cities or tourist areas with poorly planned development.

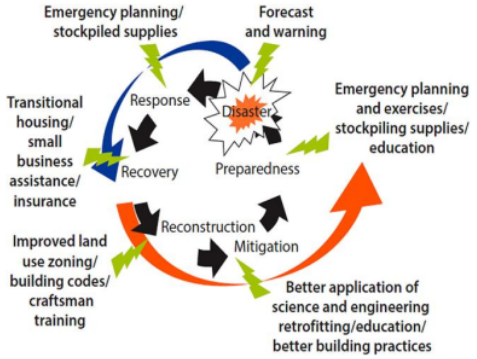

Figure 6. The Connection between Long-Term and Short-Term Risk Management Strategies for Flood and Landslide Hazards: Examples from Land-Use Planning and Emergency Management in Four European Case Studies

An integrated approach suggests not only acombination of long-term and short-term measures but alsothe interaction between the actors involved towards policyagreements for the successful implementation of risk strate-gies. This has also been stressed by the European Commis-sion, which underlines the requirement of “linking the ac-tors involved in developing and implementing measures thatcan have significant impacts on disaster prevention” [24]. Some argue that damage to dams and waterways can cause flooding. The risk of flooding can increase when heavy rain is high intensity. In addition to rainfall, the type of land cover and road pavement can trigger flood events. The rocky area causes significantly less water absorption and can cause shipping or flash floods.

Community-based landslide disaster management approaches for road network area

Based on the summary of the FGD, most community members understand that landslide is a sudden collapse of the ground or the sudden or gradual movement of large amounts of soil or rocks, which generally occurs in steep and unstable areas. The impact of erosion can partially or entirely affect the road network's performance. Factors considered to have influenced the occurrence of this disaster were bare slopes and fragile soil and rock conditions. Heavy rain is the main trigger for landslides. However, landslides can also be caused by earthquakes or volcanic activity. In addition, human activities can also cause landslides, such as uncontrolled mining of soil, sand, and stones.

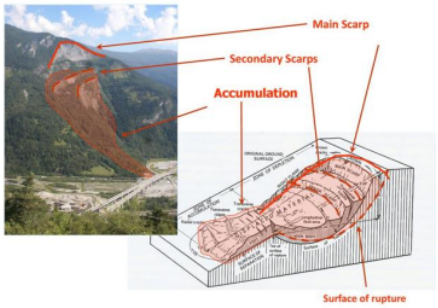

Figure 7. Factor That Many Trigger Landslide [25]

Landslides can be triggered by various factors that interact in a complex manner, including: Earthquakes can trigger landslides by destabilizing slopes or triggering the movement of unstable soil masses, The nature and type of soil, certain soil types are more prone to landslides than others. For example, clay soils have a low ability to drain water, so they tend to retain more water within them and increase the risk of landslides. Slope: Slopes with steeper or unstable slopes tend to be more prone to landslides. The gravitational pressure on the soil mass will increase with increasing slope, and this can overcome the carrying capacity of the soil and High rainfall: Intense and prolonged rains are the main cause of landslides. Rainwater that falls to the ground can fill in the cracks and reduce the carrying capacity of the soil, causing movement of soil masses and other things that may occur, for example natural changes and geological conditions.

According to the results of depth interviews, it is summarized that the initial symptoms of landslides in the road network area are four. First, cracks appear on the slope parallel to the cliff's direction. Second, the sudden emergence of water from the ground surface in the new location. The third is that the well water around the slope becomes cloudy. Finally, fragile cliffs and gravel began to fall, interfering with the road network's performance. Survey data collection shows areas prone to erosion on the road network. First, usually, there has been an erosion disaster in the area. Second, the area is steep and barren area. Third, areas with the potential for landslides are where rainwater flows. Finally, there is a tendency to have thick or very loose soils on slopes that receive high rainfall.

According to the Community, the impact of the landslide disaster in the road network area was

very detrimental to their activities. The fall of the soil material blocking the road, as in figure 3, can cause traffic flow to stop. Therefore, quick action is needed so those community activities can quickly recover.

Figure 8. Landslides Disaster in the Road Network Area

Preparedness actions were usually taken by the Community so that landslides can be minimized consisting of several steps. First, they were not cutting down or destroying forests and planting plants with strong roots on bare slopes. Second, the road network must tidy up and make rainwater channels. Third, build retaining walls on steep slopes, check soil conditions regularly, and measure rain levels.

Preparedness Measures

In the FGD, several things were conveyed about preparedness to prevent floods and erosion. First, it is better to build buildings in safe areas such as highlands and take precautions. For areas at risk of flooding. When planning and implementing the construction of a road network, it is better to understand the threat of flooding, including floods that have occurred, and know whether the area is high enough to avoid flooding. Other knowledge that must be understood is training, preparation, and safe evacuation routes. Everyone must know where to evacuate and where to go in a flood.

Communities around the road network need to develop outreach programs to increase awareness of the threat of flooding. Furthermore, it is necessary to increase public awareness to consider the threat of flooding in future developments. First, it was installing ominous signs on low bridges so as not to be crossed by people at the time of the flood. Second, make immediate repairs to bridges and supporting structures if necessary. Third, regulate the flow of water out of the area on the road network area that is at risk of flooding. The last is to put a water level sign on waterways, canals, rivers, or streams that can indicate at what height the flood will occur or the depth of the puddle. If some of these actions are carried out properly, the more significant impact of the flood disaster can be avoided.

Figure 9. Landslide Preparedness Guide [26]

Although unpredictable like most other disasters, landslides are a unique type of disaster because they can be triggered by so many different factors, as we discussed above. Landslides occur with little to no warning, so don't expect the local officials to issue an evacuation notice in advance. Main safety tip is to become aware and stay alert of any possible risks. I urge you to take extra precautions before, during, and after large rainstorms or snowstorms especially if you live in a high-risk zone and/or your region has been affected by a wildfire within the last 3 years. With that said, let's discuss some of the important safety measures you should take before, during, and after a landslide.

The Community's ability to identify and locate disaster information is excellent. Even from the information they have obtained, they can already prepare themselves for disasters that can occur at any time, especially in areas that have experienced or frequently experienced disasters. The low ability of the Community to organize and integrate new information will also be significantly influenced by the environment in which they live. Suppose the living environment supports or has a positive influence, for example. If many people are educated and understand disaster, more or the ability to organize and integrate information into

existing understanding will be better. Conversely, in a less supportive environment, most people do not understand the new information, so that the results will be inversely proportional to the first statement.

Mitigation Program

The discussion participants certainly influenced the results of the FGD on the mitigation program. The Community and government have made various efforts to reduce the potential for flood and landslide disasters in the road network area. One of these efforts is to mitigate disaster by increasing life's safety and comfort, especially for people who live in disaster-prone locations or areas. Therefore, it is necessary to have a disaster-prone map so that the Community can be prepared to prevent and reduce casualties and damage to public facilities and infrastructure.

One of the results of the FGD is that it requires computer-based data input using a Geographic Information System (GIS). Areas prone to flood and erosion will be easier to identify using GIS. The level of vulnerability is easy to know because GIS can display records of the earth's surface conditions obtained without direct contact. In addition, it is easier to update if there is a data update, so faster and more accurate information can be generated. In practice, Community can be optimized by visualizing spatial data in its attributes and efficiently producing thematic maps [27]. [28] The use of Geographic Information Systems is beneficial because of the advantages of intercepting information without making direct contact with the field or research area and without spending much money. Communities with sufficient capacity can be given access to GIS to provide data for processing control parameter data and efforts to minimize disaster.

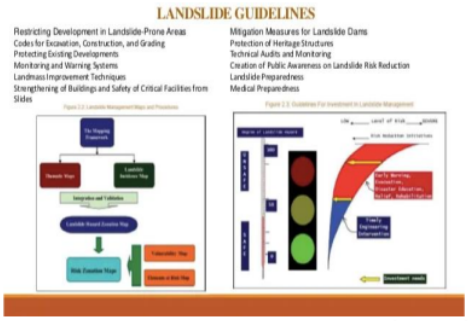

Figure 10. Disaster Management Flooding and Landslide [29]

Because based on the results of interviews, most people already know about the potential for flood and landslide disasters in their area. They are also trying to learn how to deal with landslide prevention in their area. Many informants provided information that landslides could be prevented by planting trees in landslide-prone areas. The Community also knows the importance of not cutting down trees indiscriminately and doing reforestation. This information will be significant if it can be updated on the GIS page with a specific verification process.

The results of field visits to the Community showed that they hoped to gain more knowledge about anticipating flood and landslide disasters. Suppose there is training on landslide disaster mitigation [27]. In that case, the Community will understand and be aware of the importance of disaster management, so that community participation in helping each other and maintaining the surrounding environment will increase. The government can conduct socialization with the Community regarding the potential and vulnerability of disasters. Proper socialization can reduce the negative impact of disaster events.

Optimization of social media communication

The need for information about the location, assistance, and data collection on road network damage and disruption is increasingly important as the disaster area expands [30]. With various digital conveniences, today's Community has begun to channel information, assistance, and personnel virtually, only to convey it to those who need it in real terms. Many community groups participate in disaster management through various social media platforms such as Facebook, Twitter, Instagram, WhatsApp, and others social media. Through the system's openness, all information on handling, raising aid, and providing organized information, disaster management becomes more effective, especially during emergency response. According to the results of interviews with the Community, the benefits of social media are very high. Reports submitted via the platform are responded to very quickly. Based on data from FGD results, the average response time in handling landslides is 30 minutes at maximum. For example, an inter-community Whatsapp group (WAG) consists of the Community, NGOs, Government, and Police. The most straightforward social media platform is WAG, as seen in figure 11 (in Indonesian Language).

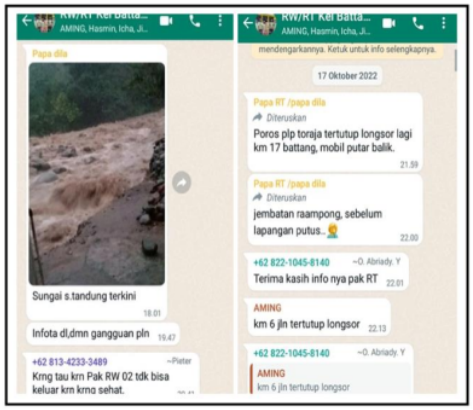

Figure 11. Example of Social Media Communication for Disaster Management Respond

Analysis search results

Based on keywords in the Scopus database,community-based AND flood AND landslides AND disaster AND management AND for AND mitigation AND of AND road AND networks AND performance then:

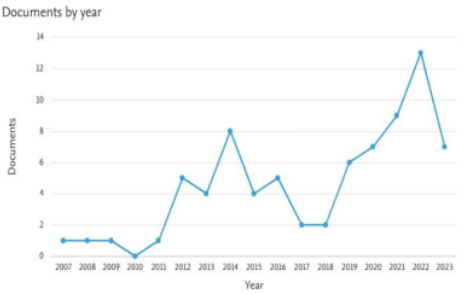

Figure 12. Documents by Year

Documents by Year in VOS Viewer is a feature that displays the year of publication of related documents in bibliometric analysis using VOS Viewer. This feature allows users to see the distribution of publications over a certain period of time, so that it can help in understanding research trends and developments of certain topics in the field being studied. By knowing the year of publication of a document, users can obtain information about how new or old a research topic is, and can assist in determining a more effective research strategy. The Documents by Year feature in VOS Viewer can assist users in visualizing and analyzing bibliometric data more effectively and efficiently.

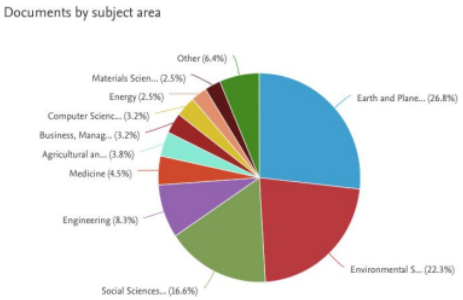

Figure 13. Documents by Subject Area

Documents by Subject Area in the VOS Viewer is a feature that displays the distribution of documents based on a particular subject or topic in a bibliometric analysis using the VOS Viewer. This feature allows users to visualize and analyze the distribution of documents on various subjects or topics, so that it can help in understanding research trends and developments of certain topics in the field studied. By knowing the distribution of documents by subject or topic, users can get information about how much research has been done in a particular field, and can help determine more effective research strategies. The Documents by Subject Area feature in the VOS Viewer can assist users in visualizing and analyzing bibliometric data more effectively and efficiently, and can assist in identifying research trends and developments of certain topics in the studied field.

Like other social media, WAG users can network with the Community. The platform is used to disseminate information and solicit responses from community members. Besides that, they can discuss trending topic issues immediately and become part of the issue. Existing technology makes it easier for human survival in various aspects of life. One example of technological developments is the development of media, from writing, print, and electronic media to social media. This technology affects people's lives with technology, especially on social media. Digital technology can be used to facilitate the delivery of disaster mitigation directives in residential areas, including road network planning.

Optimal use of WAG can encourage the success of disaster mitigation. Meanwhile, the Community uses social media to meet their information needs for natural disasters. Disseminating information through WAG technically that it is effective and efficient because, technically, it does not require significant capital, and it follows from the times. Seen from the side of the Community that it becomes useful if people disseminate disaster information, then the

information or news can be accepted by the Community.

The Community can use other social media, such as Facebook and Instagram, so the general public cannot access and accept the information or news. Information communicated through various social media platforms is about more than just disaster events. In addition, the platform is optimized to be part of the communication and information mitigation tool. Optimal communication can support the mitigation stages from preparation and handling to post-disaster recovery. By utilizing digital monitoring in community-based flood and landslide disaster management to mitigate road network performance, it is expected to increase effectiveness and efficiency in disaster mitigation and help reduce road network damage due to floods and landslides.

CONCLUSION

Based on the results of FGD, depth interviews, and survey, the results of this study can be concluded into four main results, 1) Community in the road network area has understood the causes and triggers of flood and landslide disasters that can disrupt road functions; 2) Community is willing and actively involved in disaster preparedness; 3) Community can be an essential part in the mitigation process, starting from pre, during, and after a disaster; 4) Social media platforms have optimal functions to accelerate community communication in mitigating and handling flood and landslide disasters Digital technology-based is indispensable in handling natural disasters.

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