The Role of Social Media to the Natural Disaster or Crisis Management

Vasilis Kanellopoulos, Vassilis Trianatafyllou,
Constantinos Koutsojannis and Efthymis Lekkas

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Vasilis Kanellopoulos[1], Vasilis Triantafillou[2*], Constantinos Koutsojannis[3], Efthymis Lekkas[4]

[1], *PhD Student at Department of Electrical and Computer Engineering,* University of the Peloponnese, *Patras, Greece*
[2] *Professor Department of Electrical and Computer Engineering, University of the Peloponnese, Patras, Greece*
[3] *Professor, Health Physics & Computational Intelligence Lab, University of Patras, Patras, Greece*
[4] *Professor Faculty of Geology and Geoenvironment, School of Sciences, National and Kapodistrian University of Athens, Athens, Greece*

[*]*Corresponding author: Vasilis Kanellopoulos*

ABSTRACT

The primary objective of this study is to examine the role of social media in relation to natural disasters, encompassing the periods preceding, during, and following such events. In the face of calamities, traditional communication channels tend to fail, leaving social media networks as the sole means of information exchange. Even when conventional systems collapse, including power grids, landlines, electricity, and computers, individuals still possess their smartphones equipped with internet access and relevant applications. Consequently, the significance of social media has progressively amplified in the realm of disaster preparedness, recovery, and relief efforts. Numerous mobile applications have been developed to offer assistance during emergencies. This research aims to explore whether social media platforms can effectively serve as valuable tools, fostering collaborative endeavors between individuals and organizations throughout all phases of emergency management, namely mitigation, preparedness, and response. The investigation draws upon a comprehensive literature review and empirical analysis, examining notable cases across prominent social networks like Facebook, Instagram, Twitter, YouTube, among others.

The advent of novel technologies since the mid-1990s has given rise to web-based applications commonly referred to as "social media," facilitating interactive communication and information retrieval for users. Connected social networking sites have gained immense popularity and have proven applicable in various contexts, leading numerous researchers to propose them as comprehensive solutions during emergency situations, often termed an "on-stop shop" (OSS) solution. The findings of this exploratory research underscore the consideration of connected social networking sites as a feasible remedy for the challenges surrounding information dissemination and communication within the emergency sector. Moreover, they demonstrate the potential of social networks as tools for gauging the severity of natural disasters and acquiring vital information and assessments.

Key-words: Social media, IoT, informatics, management, health, hazard, natural disaster

1. INTRODUCTION

In the past, the management and response to natural disasters were heavily reliant on static and predetermined methods. These approaches were based on historical data and predefined plans, lacking the ability to adapt swiftly to rapidly changing situations. However, a significant breakthrough has occurred with the advancement and widespread utilization of real-time data. This technology has revolutionized disaster management by providing up-to-the-minute information and insights, empowering decision-makers to respond promptly and flexibly to unfolding events.

By integrating real-time data streams from various sources, such as sensors, satellites, weather stations, and social media, disaster response teams can now receive live updates on the evolving situation. This wealth of dynamic information allows for more accurate assessments of the disaster's scope, magnitude, and impact on affected areas and populations. Real-time data not only enhances situational awareness but also enables better prediction and forecasting, giving authorities the means to anticipate disaster patterns and make informed decisions to protect lives and property. Additionally, it facilitates the coordination of emergency responses, allowing for the deployment of resources precisely where they are most needed at any given moment.

The newfound reliance on dynamic components in disaster management marks a significant paradigm shift from the previous static approaches. It signifies a departure from rigid, pre-established protocols towards adaptive and flexible strategies that can effectively cope with the unpredictable nature of natural disasters. Embracing real-time data has fundamentally transformed the way we perceive, prepare for, and respond to natural calamities, ultimately enhancing our capacity to safeguard communities and minimize the devastating impacts of such events.

This real-time access to information has highlighted the immense value and importance of speed in disseminating information. In light of this change, social media has emerged as a powerful tool for disaster and environmental management. It provides a platform for real-time information sharing and facilitates rapid communication among various stakeholders involved in managing disasters and environmental events. Recognizing the significance of social media in this context, this paper aims to review the existing literature on the role of social media in disaster and environmental management.

Natural disasters are complex phenomena that have far-reaching effects on society, communities, and populations [1]. Understanding and assessing the impact of these disasters on the affected population is essential for effective emergency response and relief efforts [2,3]. When natural disasters strike, they often result in significant damage to infrastructure, leading to issues such as lack of clean water, power outages, destruction of homes, and even loss of life [4]. The people residing in post-disaster areas are particularly vulnerable and require appropriate relief and support from emergency responders, including government agencies and non-governmental organizations. To ensure timely and proportionate rescue and relief operations, it is crucial to gauge the intensity of the population affected by disasters. Although the severity of a disaster's impact on the population is a fundamental concept, it lacks a rigorous definition [5].

Overall, effective management of natural disasters and environmental events relies on understanding their complex impact on communities and populations. The advent of social media has revolutionized the way we receive and share information, offering new opportunities for efficient disaster and environmental management. By leveraging the power of social media, stakeholders can work together to mitigate the impact of these events and ensure the safety and well-being of affected populations.

2. SOCIAL MEDIA IN EUROPE AND GREECE

In 2020 [6], the percentage of European citizens with a social media account reached 57%, showing a 3 percentage point increase compared to 2019. Greece, in line with the pan-European average, displayed a significant presence on social media. Social media participation in the European Union has been steadily growing over the past decade, with only 36% of Europeans using social media in 2011. Just like in other European countries [6], social media activity in Greece is particularly prominent among younger age groups. Approximately 90% of young people aged 16 to 24 in Greece have accounts on various social media platforms, slightly surpassing the European average of 87%. On the other hand, the penetration of social media among older age groups in Greece remains relatively low, as indicated by official Eurostat data.

According to the latest nationwide sample survey "Focus on Tech Life" Tips of the company Focus Bari [7] for the first half of 2021, Around 62% of Greeks aged 55-64 are active on social media, with Facebook being the most popular platform for creating personal profiles, showing a significant increase of 15% compared to the second half of 2020. Instagram and YouTube are also popular among this age group, with 51% and 45% of them using these platforms, respectively. Interestingly, TIK TOK has experienced a remarkable surge in popularity over the past year, particularly among girls aged 16-24. ;δThe overall internet penetration rate in Greece is estimated to be 97%, and among those aged 55-64, nine out of ten are now daily internet users, spending an average of 85 minutes online each day, a notable increase from the 58 minutes reported in the second half of 2020. The primary access device for all users is the smartphone, with 95% of users preferring it, and the average daily connection time from mobile devices has reached two hours. Additionally, it is believed that at least nine out of ten children aged 5-12 in Greece are active online. The tablet is their preferred device to connect, chosen by 40% of them, followed closely by smartphones (36%) and laptops (34%) [7].

Data from the Hellenic Statistical Authority (ELSTAT) reveals that the primary device used to access the internet in Greece is the mobile or 'smart' mobile phone (smartphone). In the first quarter of 2018, 81.2% of the Greek population aged 16 to 74 had internet access via smartphones. Moreover, among those who used

the internet during that period, 76.5% connected on the go from their mobile devices, outside of their homes and workplaces. These statistics highlight the increasing reliance on mobile technology for internet access in Greece.

3. RELATED WORK

People in trouble turn to what they believe is the quickest way to get help. In these cases, and many more, they turned to their preferred new media tool. This same social media technology has spawned numerous volunteer efforts in times of emergency, many of which have been instrumental in adding vital and accurate information used to positive effect by first responders and decision-makers [42].

Many studies are associated with natural disasters and social media. Social media can be used as a tool by providing information and instructions, with real-time, alerts and warnings. Social media represents one more channel for emergency services to send an alert and warnings.

Social media can also be used to indicate a willingness to help in the event of an emergency. In addition, it can improve the disaster response by mobilizing online volunteers far away from the epicenter of the crisis to relay information provided by emergency services. Social media can be used to identify both survivors and victims.

Recent disasters have shown an increase in the significance of social media for both affected citizens and volunteers alike in the coordination of information and organization of relief activities, often independently of and in addition to the official emergency response. During disasters, social media are widely used by people to share information, opinions, experience, and request for urgent needs.

These platforms provide tremendous opportunities to detect disaster situations and give insight into their severity. Since disaster happens suddenly, people face a significant challenge to find credible information and take suitable reactions.

Social media has become an essential tool in disaster management and response due to its widespread adoption and instantaneous communication capabilities. Here are a few examples of how social media is used in disasters:

Emergency Alerts and Updates: Authorities and relief organizations use social media platforms like Twitter and Facebook to disseminate critical information quickly. They can share evacuation orders, weather updates, road closures, and safety guidelines, helping people stay informed and make informed decisions during a crisis.

Crisis Communication and Coordination: Social media enables real-time communication between emergency responders, government agencies, and affected communities. It helps coordinate rescue efforts, allocate resources efficiently, and collaborate with different stakeholders involved in disaster response.

Requesting Help and Reporting Incidents: During disasters, people can use social media to ask for help, report incidents, and share their locations. This user-generated information can be valuable for responders to identify areas with the most significant needs and prioritize their efforts accordingly.

Crowdsourcing Information: Social media serves as a powerful crowdsourcing tool, allowing individuals to share photos, videos, and firsthand accounts of the disaster's impact. This information can provide valuable insights for responders and help in assessing the extent of the damage.

Fundraising and Donations: Social media platforms facilitate fundraising campaigns for disaster relief efforts. People can quickly share donation links, raise awareness about the situation, and encourage others to contribute to the cause.

Community Support and Mobilization: Social media fosters a sense of community and solidarity among those affected by disasters. It becomes a platform for emotional support, sharing stories of survival and resilience, and rallying support for recovery efforts.

Monitoring and Early Warning Systems: Social media data can be monitored and analyzed to detect early warning signs of disasters or rapidly evolving situations. Advanced algorithms can process social media content to identify trends, sentiments, and potential risks.

Connecting Separated Individuals: During disasters that cause displacement, people often get separated from their loved ones. Social media can be used to reconnect family and friends by sharing information about their whereabouts and safety.

Identifying Safe Zones and Resources: Social media users can share information about safe locations, available resources, and services like shelter, food distribution centers, and medical facilities. This helps people in affected areas find assistance when needed.

Learning from Past Disasters: Social media data can be analyzed after a disaster to evaluate the effectiveness of response strategies, identify areas for improvement, and gather insights for better preparedness in future events.

It's essential to remember that while social media is a valuable tool in disaster response, information shared on these platforms must be verified and corroborated with official sources to avoid the spread of misinformation and potential panic. Therefore, it's crucial to verify information from reliable sources and use social media responsibly during such events.

In the forthcoming text, we provide several examples of how social media is utilized during natural disasters.

a. Haiti Earthquake 2010 [43]: The increasing reliance on social media and SMS for rescue response and crisis management presents intriguing challenges. In the case of Haiti, information gathered from citizens through these platforms proved to be valuable, especially when aggregated at a broader area level. However, this approach encountered several issues: there was an overwhelming amount of information to process, the speed of information delivery was sometimes questionable, dealing with non-standard formats from diverse sources and languages posed difficulties, managing volunteer communities became complex, and the utility of information at the street level was limited.

A noteworthy development during the rescue response in Haiti was the rise of a global humanitarian volunteer community. Looking ahead, it is crucial to tap into the potential of this community, enhancing collaboration mechanisms, and determining the most effective ways to utilize the information they provide. Addressing these challenges and optimizing the use of social media and SMS data can significantly improve crisis management strategies in the future.

b. Evaluating Social Media Response to Urban Flood Disaster: Case Study on an East Asian City (Wuhan, China) [44], Social media plays a crucial role in urban flood disaster events in China, facilitating information sharing on weather forecasts, traffic conditions, and eyewitness accounts. Significant time-lags were observed between precipitation peaks and public engagement, as well as between precipitation peaks and opinion message dissemination. However, messages are quickly disseminated within two hours and maintain a slow dissemination speed thereafter. Organization messages are more likely to be reposted, but their popularity declines faster compared to individual messages.

Government agency messages are more comprehensive and contain more early warning information than news organizations. Public engagement with organization messages lasts for three days or longer. Messages posted by celebrities are easily disseminated on social media. However, the public lacks sufficient disaster awareness and often perceives natural disasters as distant events. The government has not effectively utilized social media for two-way communication, hindering the rapid dissemination of useful warning information. Findings suggest that credible messages from organization accounts should be disseminated more quickly and widely after disasters. Adding opinions content to these messages could enhance information persistence. Understanding the time-lag effect between public response and precipitation can benefit the study of disasters with similar time-lag effects. In future research, factors like users' demographics (gender, age, occupation, location) should be considered. Exploring the public's response to emojis, pictures, and videos during disasters on social media is essential. Additionally, understanding the public's involvement in all disaster stages (preparation, response, mitigation, and recovery) is worth further investigation.

c. The Self-Organization of Digital Volunteers across Social Media: The Case of the 2013, European Floods in Germany [45], Social media have been regularly used during emergencies for almost 15 years. The 2013 European floods serve as an instructive example of their widespread use during large-scale scenarios in Europe. Citizens and volunteers affected by the floods utilized platforms such as Twitter, Facebook, and Google Maps to coordinate help activities. Through a qualitative analysis of emergent volunteer communities in Germany on social media and interviewed group founders and activists, the study [45] focused on the use of social media during the event, particularly by digital volunteers and the role of moderators. The results emphasize the different ways Twitter and Facebook were utilized, with Twitter mainly used for status updates and Facebook pages intended for other purposes. The study highlights the relevance of social media for German citizens during disasters and sheds light on the challenges faced in organizing volunteer efforts through these platforms.

Existing research mainly focuses on the way in which individual platforms are used by volunteers in response to disasters. The information shared on social media can be extremely valuable for emergency responders and decision-makers to gain situational awareness, identify urgent needs, and plan relief efforts. Besides, this information can be helpful to immediately identify affected people during an evacuation procedure.

Four main social media functions are identified: (a) information dissemination, (b.) disaster planning and training, (c) collaborative problem-solving and decision-making, and (d) information gathering. These functions are then mapped onto the three crisis management phases of preparedness, response, and recovery to describe how a range of social media tools may be used to enhance crisis communications.

Crisis management [17] can be broadly divided into three phases: (I) crisis preparedness, (II) crisis response, and (III) crisis recovery (Table1).

a. During the crisis preparedness phase, the focus is on preventive activities that seek to reduce known risks that could lead to a crisis. Recognizing that not all crises can be averted, there would be an equal focus in this phase on crisis management planning and training of the crisis management team.

b. During crisis response, the focus will be on the speed and effectiveness of the initial response. There will be a need for quick situational awareness to help authorities respond effectively after the crisis hits. The effective use of social media tools will be critical during this phase to engage community networks in order to gather, analyze and disseminate information in a timely manner.

c. While the immediacy of response has passed, the crisis recovery phase requires longer-term planning and support to restore the situation back to normalcy.
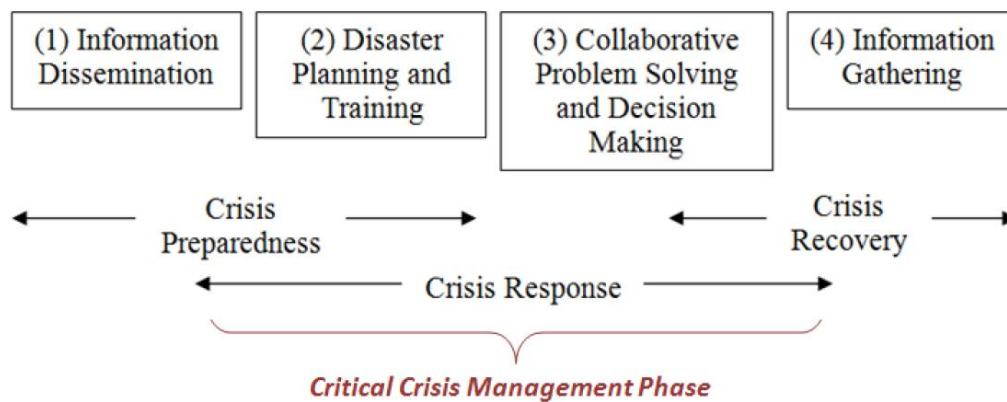

Figure 1: Social Media Functions for Crisis Management

Table 1.[17]

4. NATURAL DISASTER MANAGEMENT

Systems developed enable real and virtual help activities to be addressed although some limitations have also been recognized. Their emergent relationship with official responders has also been well-attested. Social media have been extensively used during various disasters. Studying both social media and traditional media offers valuable insights to emergency responders during natural disasters. Sentiment analysis, especially focusing on social media posts from the affected population, plays a crucial role in the comprehensive analysis of media data.

Some illustrative instances of natural disasters include the following cases:

- *The 2013 Central European floods* [9]. Sentiment analysis is a dynamic field of research that seeks to recognize public opinions and attitudes in specific contexts. Although the term suggests identifying a range of emotions like anger, disgust, fear, happiness, sadness, and surprise, the majority of sentiment analysis methods focus on a simpler task of classifying texts as either positive or negative. Despite the extensive literature in this area, most studies have centered on English movie and product reviews, leaving other domains and languages relatively less explored. **SentiSAIL** is a tool that builds upon SentiStrength, incorporating modifications and extensions. It applies sentiment analysis to social media posts in German related to the Central European floods of 2013. The results show a dominant negative sentiment throughout the disaster, which is expected due to the nature of the event. However, there are some deviations from the general negative trend, indicating potential bot activity. Ongoing work involves investigating temporal patterns and user connections during different disaster phases. Another focus is to link communication patterns to messages of resilience. In the study conducted by Gonçalves et al. (2013), eight state-of-the-art sentiment analysis methods were compared using two English datasets from Online Social Networks messages. The methods under scrutiny were SentiWordNet, SASA, PANAS-t, Emoticons, SentiStrength,

LIWC, SenticNet, and Happiness Index. The research revealed that these existing sentiment analysis methods demonstrated varying levels of applicability when applied to real-world events. The agreement among these methods regarding the predicted polarity of social media texts was found to be widely different. This indicated that the same text was interpreted differently based on the choice of the sentiment analysis method used. Furthermore, all the examined methods showed substantial variations in their sentiment predictions for significant social events. For instance, in the case of an airplane crash, half of the methods predicted the majority of relevant tweets to contain positive affect, which was deemed implausible given the nature of such an incident. This study highlights the importance of carefully selecting sentiment analysis methods, especially when dealing with real-world events, as their effectiveness and accuracy can differ significantly.

- _Hurricane Harvey in August and September of 2017_. In the case of Hurricane Harvey, Mayor Turner did an exemplary job of communicating through Twitter but could have included more tweets with inclusive language and more local hashtags earlier in the crisis. It provides us with a compelling illustration of how social media, particularly Twitter, can be used in a crisis to provide information, guidance, reassurance and hope to key publics through a case study examining the usage of Twitter by Houston, Texas mayor Sylvester Turner, during Hurricane Harvey in August and September of 2017. This article [48] uses restorative rhetoric as a theoretical framework to analyze Mayor Turner's Twitter posts from the mayor's official Twitter account before, during and after the crisis. From this analysis, the article offers suggestions on how Twitter, and social media in general, can help crisis managers prepare for, communicate during, and move forward following a natural disaster.

- _The 2019 flood in Polland_. The article [49] aims to discuss the role of social media platforms, Facebook and Twitter, during the floods that occurred in Poland in May 2019. The flood resulted from heavy rains and storms, causing severe flooding in parts of eastern and southern Poland and extensive damage. Over 8,000 hectares of land were submerged, leading to the evacuation of 4,000 residents and 5,000 animals. Tornadoes accompanying the flood caused additional damage to buildings, prompting the issuance of the highest flood warning level. Emergency services, including fire brigades, the army, and Territorial Defence Forces, were deployed to coordinate and manage the crisis to protect and support local communities. The study analyzed a corpus of text posts and tweets related to the flood event on social media platforms. The analysis aimed to understand the sentiments expressed in these online communications and categorized them into three groups: positive, negative, and neutral (objective).

The majority of flood-related posts (48.9%) were classified as neutral, indicating that they did not show any strong emotional sentiment. Positive sentiment posts accounted for a small portion (2.1%) of the sample, expressing appreciation and acknowledgment for the work of emergency services and individuals involved in successful rescue operations during the flood. Compassionate sentiments were identified in 5.2% of the posts, primarily expressing concern and empathy for animals affected by the flood. Social media users organized online donations and assistance in evacuating animals, particularly addressing the problem of flooded animal shelters. However, not all sentiments expressed were positive or compassionate. Negative sentiment posts constituted 43.5% of the online comments related to the flood. Some of these messages (1.6%) conveyed fear or threat, discussing the disastrous consequences of climate change and urbanization on the environment. The study also found that 4 out of 10 posts and tweets were strongly negative, highlighting the presence of hate speech in online conversations related to the flood and other sensitive topics. Overall, the analysis revealed a diverse range of sentiments expressed on social media during the flood event, ranging from positive acknowledgments and compassionate responses to criticism and negativity, including hate speech.

4.1 TWITTER: THE PROTAGONIST

Twitter has played a crucial role in natural disasters management due to its unique features and widespread use. Twitter, in particular, is often referred to as the 'most useful social media tool' particularly for natural disasters (Liu et al., 2012, p. 362). However, social media is not yet used to its full potential in crisis communications (Lin et al., 2016) and more research is needed on social media and crisis communication (Eriksson and Olsson, 2016; Spence et al., 2016).

However, please note that the landscape of social media platforms and their roles in various aspects may have evolved since then. Here are some ways Twitter has been important in natural disasters management:

- Real-time updates: Twitter allows users to post short messages (tweets) in real-time. During a natural disaster, people can quickly share information about the situation on the ground, such as the extent of damage, emergency response efforts, and updates on rescue operations. These real-time updates enable authorities, relief organizations, and affected communities to stay informed and coordinate their actions effectively.

- Crisis communication: Public agencies, emergency services, and disaster response organizations often use Twitter to disseminate critical information to the public during a disaster. They can issue alerts,

evacuation notices, safety guidelines, and other essential instructions through official accounts. This direct communication channel helps reach a large audience quickly, facilitating timely actions and reducing misinformation.

- Crowd-sourced information: Twitter enables users to share their experiences and observations during a disaster. This crowd-sourced information can provide valuable insights into the situation on the ground, including areas of urgent need, potential hazards, and areas where assistance is required. Disaster management authorities can monitor these tweets and use the information to make data-driven decisions.

- Human connection and support: During natural disasters, affected individuals often turn to Twitter to seek help, offer support, or locate missing persons. The platform serves as a virtual community where people can connect, share their stories, and provide emotional support to those impacted by the disaster.

- Hashtags and trending topics: Twitter's hashtag system allows users to tag their tweets with relevant keywords, making it easier to track information related to a specific disaster. Hashtags related to a disaster often trend, gaining widespread attention and encouraging more people to share and engage with relevant content. This increased visibility can help raise awareness, promote fundraising campaigns, and mobilize support for relief efforts.

- Monitoring and situational awareness: Emergency responders and disaster management agencies use Twitter as part of their social media monitoring efforts. Analyzing Twitter data can provide valuable insights into the public's sentiment, needs, and concerns during a disaster, helping authorities tailor their response strategies accordingly.

- Despite the significant role Twitter plays in natural disasters management, it's important to note that social media platforms, including Twitter, also face challenges during these events. Misinformation and rumors can spread quickly, potentially hindering relief efforts and causing panic. Therefore, responsible use of social media and cross-referencing information from reliable sources remain crucial during disasters.

- As the social media landscape continually evolves, new platforms and tools may emerge to complement or enhance disaster management efforts further. It's essential for disaster management professionals to stay updated on the latest technologies and best practices to leverage social media effectively during emergencies. Starbird & Palen [1] suggested that personal relationships with people affected and the pure desire to help were the initial reasons for using Twitter. The prospect of identifying, amplifying and redirecting information was examined in multiple studies, which highlight the role of retweeting, outline the phenomena of information broadcasting or information processing through filtering [2]. The process of information broadcasting, another crucial aspect of social media, involves the mass dissemination of information to a broad audience. This can occur through various means, such as trending topics, hashtags, and influential users sharing content. Information broadcasting can have a significant impact on public discourse, shaping opinions, and driving discussions on various subjects.

On the other hand, information processing through filtering plays a crucial role in managing the overwhelming amount of content available on social media platforms. Users are bombarded with an enormous volume of information daily, making it challenging to stay informed and relevant. Filtering mechanisms, such as personalized algorithms and content curation, help users navigate through this vast sea of data and present them with content that aligns with their interests and preferences. Consequently, filtering mechanisms have a profound influence on what information users are exposed to and, in turn, affect the narratives and opinions they develop. Social media platforms have acknowledged the significance of filtering and have invested heavily in developing algorithms that optimize content distribution based on user behavior, interests, and engagement patterns. While these algorithms aim to enhance user experience, they have also raised concerns about the potential for creating echo chambers, where users are primarily exposed to information that aligns with their existing beliefs, limiting exposure to diverse perspectives. Moreover, the role of social media in information dissemination has had far-reaching implications in various spheres, including politics, public health, and social activism. The speed at which information can be shared on social media has enabled real-time reporting and has played a crucial role in mobilizing communities during emergencies or social movements.

However, the spread of misinformation and disinformation on social media has also become a significant challenge. False or misleading information can circulate rapidly, leading to confusion, panic, and even harm in some cases. Platforms and researchers continue to grapple with developing effective strategies to combat misinformation without infringing on freedom of speech. Overall, the study of how information is identified, amplified, and redirected on social media is a continuously evolving field. Understanding the dynamics of social media information dissemination is essential for users, policymakers, and platforms to harness the positive aspects of social media while mitigating the negative consequences.

Another important aspect is the verification of information as there are obvious issues regarding the perceived credibility of social media content in comparison with other media. Information with no clear source, for instance, can be implicated in the spread of rumor.

Disaster organizations play a crucial role in managing and responding to various types of disasters, whether they are natural calamities like hurricanes, earthquakes, or human-made incidents such as industrial accidents or terrorist attacks. These organizations typically involve various stakeholders, including local government authorities, coordinators, citizens who provide information, and volunteers. Let's delve deeper into each of these players:

Local Government: Local governments, such as city councils or municipal bodies, are the primary authorities responsible for disaster management within their jurisdiction. They play a vital role in coordinating disaster response and recovery efforts. Their responsibilities include:

Creating disaster management plans: Local governments develop comprehensive plans outlining how they will respond to different types of disasters and allocate resources accordingly.

Coordination with other agencies: They collaborate with regional, state, and federal agencies to ensure a coordinated and effective response to disasters.

Allocation of resources: Local governments are responsible for allocating funds, equipment, and personnel to deal with emergencies.

Public communication and education: They inform citizens about potential risks and the necessary precautions to take during disasters.

Activation of emergency operations centers: These centers are activated during disasters to facilitate communication and decision-making among relevant agencies.

Coordinators: Disaster coordinators are individuals or teams designated to manage disaster response efforts. They work under the guidance of local government or emergency management officials and are responsible for:

- Assessing the situation: Coordinators evaluate the scale and impact of the disaster to determine the appropriate response measures.

Mobilizing resources: They coordinate the deployment of emergency services, personnel, and supplies to affected areas.

- Communication: Coordinators maintain communication with various response teams, government agencies, and stakeholders to ensure an integrated approach to disaster management.

- Incident Command System (ICS): Coordinators often use ICS, a standardized management system, to efficiently manage resources during disasters.

- Citizens who give information and accept consequences: During a disaster, citizens play a crucial role as both sources of information and active participants in disaster management. They contribute in the following ways:

- Reporting incidents: Citizens report emergencies and provide essential information to emergency services, aiding in faster response times.

- Following instructions: In disaster-prone areas, citizens must be prepared to follow evacuation orders, seek shelter, or take other necessary precautions to protect themselves and their communities.

- Participating in community efforts: Citizens may volunteer to assist in various tasks, such as setting up shelters, distributing supplies, or helping with search and rescue operations.

- Volunteers: Volunteers are individuals who selflessly offer their time and skills to support disaster response and recovery efforts. They are a critical asset to disaster organizations and bring various expertise to the table:

- Search and rescue: Trained volunteers help in locating and rescuing people trapped in disaster-stricken areas.

- Medical support: Medical professionals and first aid-trained volunteers provide essential medical care to the injured.

- Relief operations: Volunteers help in distributing food, water, clothing, and other necessary supplies to affected communities.

- Psychological support: Volunteers with counseling skills provide emotional support to survivors and affected individuals.

- Reconstruction and recovery: Volunteers assist in rebuilding communities and infrastructure after the disaster.

Overall, the effective collaboration and cooperation among these players are vital for a successful disaster management and response process, as it helps minimize loss of life and property and ensures a quicker recovery for affected communities.

4.2 FACTORS AND PLAYERS IN NATURAL DISASTER

In the context of natural disasters management, moderators are factors or players that can influence the severity of the impact and the effectiveness of disaster response and recovery efforts. These moderators can either mitigate or exacerbate the effects of natural disasters. Here are some key moderators in natural disasters management:

Preparedness Measures: The level of preparedness in a community or region significantly affects how well they can cope with a natural disaster. Preparedness includes having well-designed disaster management plans, early warning systems, evacuation routes, and community education programs. Communities with robust preparedness measures are more likely to respond effectively and reduce the loss of life and property during disasters.

Government Policies and Regulations: Government policies related to land use, building codes, and zoning regulations can influence the vulnerability of an area to natural disasters. For example, strict building codes that consider earthquake-resistant structures in seismically active zones can mitigate damage during earthquakes. Effective disaster management also relies on clear and efficient decision-making processes at all levels of government.

Community Engagement: The level of community engagement and participation in disaster management can make a significant difference. Communities that actively engage in disaster planning, response, and recovery efforts tend to fare better during disasters. Social cohesion, community organizations, and mutual support networks can strengthen disaster resilience.

Technological Advancements: Advancements in technology, such as satellite-based monitoring systems, early warning systems, and communication tools, play a critical role in disaster management. These technologies can enhance preparedness, improve situational awareness, and facilitate timely response actions.

International Cooperation: In the case of large-scale or transboundary disasters, international cooperation and support are crucial. Coordination between countries and international organizations can provide additional resources and expertise to affected regions.

Topography and Geography: The geographical characteristics of an area can influence the impact of certain natural disasters. For instance, low-lying coastal areas are more susceptible to flooding during hurricanes or tsunamis, while mountainous regions may face higher risks of landslides.

Climate Change: The effects of climate change, such as rising sea levels, increased frequency and intensity of extreme weather events, and changes in precipitation patterns, can exacerbate the impact of natural disasters. Managing the risks associated with climate change is a critical aspect of disaster management.

Economic Development: The level of economic development in a region can affect its ability to cope with and recover from disasters. Wealthier regions may have better infrastructure, healthcare facilities, and financial resources to support recovery efforts.

Media and Public Perception: The way disasters are portrayed in the media and perceived by the public can influence the response and recovery efforts. Accurate and responsible media coverage can help mobilize support and resources, while misinformation or panic can hinder effective management.

Cultural Factors: Cultural beliefs, practices, and traditions can impact disaster management. Understanding and incorporating cultural considerations into response plans can improve communication and cooperation during disasters.

Managing natural disasters requires a comprehensive approach that takes into account these various moderators. By addressing vulnerabilities, enhancing preparedness, and promoting collaboration among stakeholders, disaster management efforts can be more effective in reducing the impact of natural disasters on communities and the environment.

Volunteer role classifications include "helper", "reporter", "retweeter", "repeater" and "reader" [3] as well as "information broker", gathering and reporting information. Kaufhold & Reuter [4] suggest "moderators", who establishes supportive platforms for real and virtual activities, mediates offers of and requests for assistance, mobilizes resources and integrates information of various sources.

4.3. SYSTEM DEVELOPMENT PROCESS

A recent (2019) comparison [15] of the afore mentioned platforms and others based on the following criteria:
Input data: emphasizes if the system uses social media platforms or other sources in its implementation.
Visualization: shows if the system utilizes data visualization techniques.
Real-time analysis: underlines if the system process social media data in real-time.
Sentiment analysis: indicates if the system performs sentiment analysis on social media data.

Event detection: specifies if the system performs event detection.

Real-time recommendation: shows if the system provides real-time recommendations.

User: indicates who can use the system.

As shown in the Table 2 [15] (article ´´Towards A Social Media-Based Framework for Disaster Communication´´, Procedia Computer Science, Volume 164, 2019) below, most of the platforms work only on Twitter streams such as TweetTracker [18], TweetXplorer [20], Tweet4act [22], TweetCred [35], Tweak the Tweet [29], Twitcident [28], Twitris [30], SensePlace2 [33], Tweedr [34] etc. Some other platforms, such as MoDisSENSE[26], Twitcident [28], and XHELP [32] consider data disseminated on other social networks. The interesting thing is that four platforms, SMART-C, MoDisSENSE, TweaktheTweet and SURRICATE, indicate citizens as users, while all the other indicate organization.

Methodology utilized in the AIDR [21,39] platform for annotating social media messages, by combining human expertise with automated algorithms, the proposed solution aims to enhance the comprehension and utilization of aerial data in disaster response scenarios. To put it differently, when it comes to crowdsourcing, there is an unresolved problem of effectively balancing the tradeoffs between task quality, cost, and time, especially in the midst of emergencies. Moreover, the information flow within the system needs to be automated to prevent processing delays caused by a scarcity of workers or insufficient incentives to motivate them. the importance of leveraging both human and machine capabilities to overcome the challenges posed by the increasing volume and complexity of data in disaster situations.

JORD [27] is a system that aims to gather information about natural disasters by autonomously collecting social media data and linking it to remote-sensed data. It addresses the limitations and challenges associated with using satellite imagery alone by leveraging the additional information available through social media.

SMART-C gives a real-time communication which is crucial before, during and after a natural disaster, according to Crisis management (Table 1) [17]. The vision of SMART-C is to design a flexible platform to support two-way responder/citizen collaboration that uses social media to enhance communications before, during, and after an emergency. In contrast to all the other platforms, SMART-C incorporates input from multiple sources such as social media feeds, multimedia messaging, and citizen reports into alert generation. Data from such sources could significantly improve reliability, accuracy, and customization. SMART-C additionally offers the ability for geo-spatial analysis for fine-grained customization of alerts (e.g. geocontext such as vicinity to chemical factories). Finally, the policy-based alerting platform in SMART-C enables alerting functionality during all phases of the disaster lifecycle.

Some of them are indicative:

- Hands2Help [11] is a mobile app concept which intends to coordinate volunteers in terms of supply and demand of help, enabling ad hoc registration and allowing efficient allocation and monitoring. An exceptional solution is the Tweak the Tweet [29] micro syntax for Twitter, allowing the automatic classification of information by means of specific hashtags and tweet structure. It is the only approach, which aims to improve methods of public information gathering and dissemination during emergency situations and is integrated in an existing network but has syntactical requirements and is limited to Twitter.
- MoDisSENSE [26] is dedicated to citizens by involving "connected citizens" actively in natural disaster reporting and prevention such as, a distributed platform that detect trending events and provide personalized search for points of interest on the basis of criteria like place, time, feeling or a combination of the above.
- SURICATE-Nat [36] which aims to collect tweets on natural disasters and process the data to provide information on risks and risk prevention.
- SMART-C [25] project which represents a high-level framework for detection and alert dissemination. Until now, this project is not implemented.
- CrisisTracker [24] Situation awareness is the main precursor to appropriate decision making [40]. Social media, in particular Twitter, has emerged as a new source of citizen-generated reports that can potentially offer a detailed real-time view of the situation on the ground during large-scale complex disasters. As physical access to affected areas can be restricted and no response organization has resources to be everywhere, such cheap distributed sensing mechanisms are highly attractive during mass disaster and conflict. During crises affecting millions of people, it is not uncommon to see hundreds of thousands of social media messages being generated every hour and information management tools are needed to effectively extract and organize relevant information in real time. However, social media messages have proven difficult to process using traditional natural language processing algorithms and most success stories in the disaster space have relied on organized crowds of volunteers who process content manually.

Platforms	Input data	Real time analysis	Event detection	Sentiment analysis	Visualization	Real time recommendation	User
1.TweetTracker [18]	Twitter	X	X		X		Organization
2.AsonMAps [19]	Twitter Instagram	X			X		Organization
3.TweetXplorer [20]	Twitter	X			X		Organization
4.AIDR [21]	Twitter	X					Organization
5.Tweet4act [22]	Twitter	X					Organization
6.Ushahidi [23]	Twitter Email, SMS, RSS feeds	X	X		X		Organization
7.CrisisTracker [24]	Twitter, Instagram	X	X				Organization
8.SMART-C [25]	Twitter, Facebook, Text message, Cell phones, MMS Message	X	X			X	Citizen
9.MoDisSENSE [26]	Facebook, Foursquare	X	X				Citizen
10.JORD [27]	Twitter, Flickr, Youtube, Satellite imagery	X	X				Organization
11.Twitcident [28]	Twitter	X	X		X		Organization,citizen
12.Tweak the Tweet [29]	Twitter	X					Citizen
13. Twitris [30]	Twitter, SMS	X	X	X	X		Organization
13. TwitInfo [31]	Twitter	X	X	X	X		Organization,citizen
14. XHELP [32]	Twitter	X					Volunteers
15. SensePlace2 [33]	Twitter	X	X		X		Organization
16. Tweedr [34]	Twitter	X					Organization
17. TweetCred [35]	Twitter	X			X		Organization
18.SURICATE-Nat [36]	Twitter	X	X				Citizen

Table 2

4.4. SYSTEMS ANALYSIS

Most platforms apply to twitter and some disseminate data to other platforms.

Few platforms, however, use both social media and other kinds of input data like Email, SMS, Cell phones, and satellite imagery, for example, SMART-C, Ushahidi, JORD, and Twitris.

All platforms presented, except XHELP, Ushahidi, and AIDR, perform real-time analysis on input data.

Only SMART-C provides real-time recommendations based on data analysis results, which reduces the efficiency of these platforms in helping stakeholders take suitable decisions and save lives during the disaster. While most emergency management platforms carry out event detection and data visualization through maps and graphs, few of them, namely Twitris and TwitInfo, perform sentiment analysis on input data.

To summarize, almost all approaches (Table 2) have limitations when used by volunteer moderators in disasters: They either demand syntactical requirements from the user; do not provide cross-platform structures, e.g. focus solely on Twitter, or require the use of a new platform and therefore fail to integrate ICT for volunteers into existing networks (almost all).

Few cross platforms

Almost all real-time analysis

Most event detection (10 out 0f 18)

Sentiment analysis (2 out of 18)

Medium Visualization (9 out of 18)

Real time recommendation (1 out of 18)

Misusing a platform or relying on only one platform can lead to the public's not becoming fully aware and informed of natural disasters and their danger. Ultimately, disaster relief professionals should employ various social media tools and approaches when coordinating disaster relief efforts.

Understanding how to use the various tools and functionalities built in platforms like Facebook, Twitter, Instagram, YouTube and Snapchat is beneficial. However, it involves devising and executing a specific strategy for each platform, such as using Facebook to share longer information of evacuation instructions for a hurricane, while using Twitter to display immediate information on the hurricane's development itself.

How a disaster relief professional or organization chooses to use social media varies by the reach and size of the social media audience. The fire department of one city may have a robust Twitter presence, while that of another community may have a greater number of Facebook followers. These factors should be considered when developing strategies to make sure that information reaches as many people as possible.

Disaster relief professionals should also be prepped in best practices for communicating with social media users before, during and after the disaster. This can include designating and promoting a social media platform as a place where individuals can leave questions or clearly communicating to users what type of information they can expect to receive — and when — on certain social media accounts.

Disaster relief officials should also tackle unexpected developments in their social media efforts and make changes when necessary. For example, a government agency may find that certain Facebook posts perform better using an image rather than accompanying text. Knowing this, the officials can adjust or pivot their strategy to ensure that their message reaches as many people as possible.

Overview and avoiding barriers of usage: The basic principle of a Facebook application that enables interaction patterns, the display and content of social media already in use is demonstrably beneficial, according to our respondents.

User-defined information management: A custom information management is required because of the varying preconditions, assessments and working procedures of the participants.

Support for self-assessment and information verification: The participants wanted support for information assessment according to specific qualitative criteria to enable them to search purposefully through the vast flood of data in social media. At the same time, they expressed a desire to self-evaluate posts or comments and to highlight relevant comments. Such a function could be used to improve the filtering and classification of upcoming search queries.

Amplify potential for cross-platform networking: Interviewees see advantages in cross-platform information processing because faster responses are possible, and the general view of the integrated platforms reduces management effort. The functionality of finalizing postings is perceived as assistance to formulating cross-platform status updates and to finishing help activities.

Social media is constantly evolving, and best practices for its use by emergency officials will change as well. It's important for them to monitor and update their social media practices frequently by attending social media workshops and seminars, obtaining certifications, and reading updates and articles from publications that focus on and highlight social media. Being on top of the latest social media trends will enable emergency management and disaster relief personnel to better serve citizens and save lives.

5. STUDY RESULTS

A cumulative total of more than 150 articles that satisfied the established inclusion criteria were identified. The prevailing majority of these studies encompassed qualitative and quantitative research methodologies, complemented by a smaller number of case studies and reviews. These studies comprehensively encompassed a diverse array of natural calamities and environmental incidents, including hurricanes, floods, wildfires, and oil spills.

On the whole, the findings derived from these studies indicate that social media plays a pivotal role in the realms of disaster and environmental management, acting as a potent instrument for furnishing real-time information and expediting communication between relevant stakeholders. Prominent social media platforms like Twitter and Facebook serve as indispensable conduits to disseminate crucial instructions, evacuation directives, and emergency alerts to affected communities. Furthermore, social media platforms prove invaluable in mobilizing volunteers and orchestrating concerted response endeavors.

Notably, social media assumes an important role in the aftermath of disasters and environmental incidents, functioning as a platform where individuals can share their experiences and forge connections with one another. It emerges as a formidable tool for monitoring on-ground situations and identifying regions necessitating utmost attention.

Nevertheless, the studies also underscore certain limitations and challenges related to the utilization of social media in the context of disaster and environmental management. One prominent challenge lies in the overwhelming volume of information that officials must contend with, making it arduous to discern authentic and reliable data from falsehoods or deceptive content. Additionally, the usage of social media introduces concerns regarding privacy and legal ramifications that necessitate careful consideration.

6. CONCLUSIONS

The literature reviewed in this paper suggests that social media can play a critical role in disaster and crisis management, by providing real-time information and facilitating rapid communication among stakeholders. However, it is important to be aware of the limitations and challenges associated with the use of social media and to develop strategies to address these issues. Twitter [31] is fast becoming a critical source of information about world events large and small. However, it is difficult to translate this information into a format allows users to draw higher-level conclusions. Twitter is a useful tool for crisis management in natural disasters due to several key reasons:

-   Real-Time Information: Twitter enables real-time communication and information sharing. During a natural disaster, people on the ground, government agencies, and organizations can quickly disseminate critical updates, warnings, evacuation notices, and emergency instructions. This helps to keep the public informed and aware of the latest developments, facilitating prompt action and reducing potential risks.

-   Rapid Communication: Twitter's platform allows for rapid communication and direct interaction between different stakeholders. Emergency management agencies can quickly respond to queries, address concerns, and provide clarifications. Likewise, affected individuals can reach out to authorities, report incidents, or request assistance. This instant exchange of information enhances coordination and helps to streamline response efforts.

-   Wide Reach: Twitter has a vast user base, including individuals, organizations, and news outlets. During a crisis, tweets related to the event often go viral, reaching a large audience. This widespread dissemination of information is crucial for increasing public awareness, mobilizing support, and promoting a sense of solidarity. Moreover, journalists and media professionals often monitor Twitter to gather news, amplifying the reach of crucial updates and emergency messages.

-   Community Support and Engagement: Twitter fosters community support and engagement during crises. Users can share their experiences, offer help, and organize relief efforts. This enables affected individuals to connect with each other, exchange valuable resources, and provide emotional support. Additionally, Twitter users often collaborate to verify and fact-check information, ensuring the accuracy of shared content and preventing the spread of misinformation.

-   Data Collection and Analysis: Twitter generates a vast amount of data during natural disasters. This data can be analyzed to gain insights into the impact of the event, assess public sentiment, identify emerging issues, and evaluate the effectiveness of response efforts. This information is valuable for emergency management agencies, as it helps them make data-driven decisions, allocate resources efficiently, and improve future disaster response strategies.

-   Public Awareness and Education: Twitter serves as a platform for public awareness and education regarding natural disasters. Government agencies, NGOs, and experts can share tips on preparedness, safety precautions, and recovery strategies. This empowers individuals and communities to take proactive measures, increase their resilience, and minimize the impact of future disasters.

It is important to note that while Twitter can be a valuable tool for crisis management, it also has limitations. These include the potential for misinformation to spread quickly, the need for reliable internet access during emergencies, and the challenge of filtering and prioritizing relevant information from the vast volume of tweets. However, when used effectively and in conjunction with other communication channels, Twitter can significantly enhance crisis management efforts during natural disasters.

Over the course of the past ten years, there has been a remarkable surge in research and investigation concerning the relationship between social media and disasters. This burgeoning interest has led to a wealth of knowledge and insights that hold tremendous potential to enhance disaster management and response strategies. Consequently, conducting a comprehensive review and analysis of these existing studies becomes imperative as it can serve as a compass, skillfully guiding researchers and planning entities towards the implementation of more effective disaster management and response practices.

By delving into the vast body of research in this domain, researchers and planners can glean valuable lessons and best practices, avoiding the pitfalls of trial and error. The amassed knowledge can act as a rich repository of experiences and findings, enabling these stakeholders to make informed decisions and design evidence-based strategies that are attuned to the complexities of social media dynamics during disasters.

Furthermore, the review of existing studies serves to bridge the gap between theoretical frameworks and real-world applications. It offers a practical and tangible foundation upon which researchers and planning entities can build their interventions, fostering a more proactive and adaptive approach towards disaster management. In essence, the culmination of studies exploring social media's role in disasters has paved the way for an exciting era of data-driven decision-making. The insights drawn from these endeavors can equip researchers and planning entities with the necessary tools to harness the potential of social media as a powerful and agile resource for disseminating critical information, coordinating relief efforts, and mobilizing support during

times of crisis. By leveraging the wealth of knowledge gained from these studies, the global community stands poised to achieve greater preparedness, resilience, and effectiveness in managing and responding to disasters of all scales.

7. FUTURE WORK

This text emphasizes the need for future research to focus on developing effective strategies for filtering and disseminating information on social media during disasters or environmental events. Additionally, there is a call for more research to determine the best ways to utilize social media in mobilizing volunteers and coordinating response efforts. The text also highlights the importance of conducting research on aerial data as it is expected to present significant big data challenges in the near future.

Regarding Sentiment Analysis, the authors intend to prioritize creating a specialized vocabulary for disasters based on social media content. This lexicon aims to categorize tweets into precise emotional types, drawing upon the field of disaster psychology. The next step is proposed as creating a social media-based platform to enhance disaster detection and communication with citizens, volunteers, and responding organizations before, during, and after a disaster. This platform seeks to involve stakeholders in co-creating security solutions through media coverage and shape citizens' and local communities' perceptions of security.

The proposed platform consists of three main functional blocks: a data collection module, a data processing module, and a recommendation module. These modules evaluate data from various sources and deliver them to citizens, volunteers, and responding organizations during a disaster, following the concept of "Citizens as Sensors," where citizens contribute data for evaluation and utilization.

To ensure robustness and security, the platform's design and development will be based on Web 3.0 and blockchain technologies. Leveraging these technologies aims to enhance data integrity, transparency, and decentralization. Overall, this framework presents a comprehensive approach to using social media and emerging technologies to enhance disaster management, communication, and citizen engagement in security-related processes. Combining Big Data Analytics and Internet of Things technologies can empower disaster management authorities with real-time data, predictive analytics, and advanced decision support systems, ultimately improving response capabilities and coordination among stakeholders, and mitigating the impact of disasters.

The level of social vulnerability is a crucial factor that affects how people react to natural disasters on social media. The study's analysis shows that the expected reactions on Twitter are not the same across all social vulnerability levels examined. The changes in tweet frequency differ significantly depending on the type of disaster and the social vulnerability of the affected population.

While Twitter can be considered a useful tool for sensing natural hazards, studies as the ; **"Quantitative analysis of social media sensitivity to natural disasters"** [50], reveals that different Twitter behaviors and metrics (such as attention duration, tweet frequency based on vulnerability, proximity, and sentiment) respond differently to various types of natural disasters. It is essential for researchers to recognize that Twitter response patterns for one type of natural hazard may not apply to other types. When evaluating Twitter responses to events like wildfires compared to tornadoes, careful consideration should be given.

Moreover, the social vulnerability of the affected population plays a distinct role in shaping their social media behavior during disasters. Some events have a more extensive impact in terms of geographical distance, may persist for a longer duration, and elicit varying responses among different subgroups of the population.

In future research, these findings will be used to delve into the quality of information and actionable content present in social media feeds during disasters. Understanding these patterns can contribute to better disaster management and response strategies.

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