Social Signals: Harnessing Social Media Data for Disaster Management

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September 26, 2023

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Abstract. This study investigates the collection of social media signals without exclusive reliance on application programming interfaces (APIs). The current research on collecting social signals for disaster management is primarily focused on APIs. This approach is valuable, but it also presents a range of challenges that need to be taken into account. Thus, the extent and regularity of data collection may be impacted, posing challenges in obtaining comprehensive and up-to-date information. In light of this knowledge gap, we put forth a compelling argument in support of non-API approaches for gathering social signals from social media platforms. To answer the research questions, a qualitative methodology employing an inductive approach was used to gather and analyze data from officers working in disaster management organizations (DMOs). By adopting this approach, noteworthy themes and patterns emerged and were carefully examined, ultimately resulting in the derivation of the research findings. The study highlights the potentials of social signals in enhancing decision-making across various phases of disaster management. Through innovative techniques, DMOs can leverage social signals from public posts, comments, and interactions to gain insights into user sentiments, opinions, and real-time updates. These insights greatly assist decision-making at different stages of disaster management, including preparedness, response, recovery, and mitigation. Overall, the study emphasizes the effectiveness of gathering social signals from social media platforms without relying solely on APIs, highlighting their potential to improve decision-making in disaster management.

Keywords: Social Signals, Social Media Data, Data Collection, Social Media Analytics, Crowd Sensing, Public Sentiment Analysis, Data-driven Disaster Management, Disaster Management, Crisis Response, Disaster Phases, Inductive Coding.

1 Introduction

In recent times, there has been an alarming increase in the intensity and frequency of catastrophic incidents, demanding urgent action. Specifically, in 2022, a total of 387 natural hazards and disasters occurred globally, leading to the tragic loss of 30,704 lives and impacting a staggering 185 million people resulting in an estimated loss of approximately 223.8 billion USD in economic losses [1]. The challenge of managing disaster risks persists due to various factors, such as climate change, population growth

driving higher agricultural demand, unplanned urbanization, and increasing pressure on natural resources. These factors contribute to the escalating global losses associated with disasters. In the digital age, social media has emerged as a powerful platform that not only connects people across the globe but also generates an unprecedented amount of data. This vast pool of information, flowing through tweets, posts, and updates, holds immense potential to revolutionize disaster management practices. By tapping into these social (data) signals, emergency responders, relief organizations, and policymakers can gain real-time insights, enhance situational awareness, and optimize their response efforts to mitigate the impact of disasters.

This work aims to provide an understanding of the utilization of social media data for managing disaster events. By examining the various ways in which social media data can be harnessed, this study seeks to shed light on the effective use of social media data in disaster management. The advent of social media platforms has brought about a paradigm shift in the way information is disseminated during disasters. From floods and earthquakes to wildfires and pandemics, people turn to social media as a primary means of communication, seeking and sharing information in real-time. As a result, social media platforms have evolved into dynamic channels that capture a wide range of critical data, including eyewitness accounts, photos, videos, and situational updates. This real-time, user-generated content forms the foundation of social media data and serves as a valuable source of information for disaster management. While the existing body of literature has provided compelling evidence regarding the value of social media in disaster management, limited knowledge exists regarding its optimal utilization across various phases of disaster management [2] [3]. Social media platforms offer diverse functionalities and capabilities, and their potential applications in the context of disasters are highly variable [3] [4] [5]. Despite being a powerful communication tool, there is a scarcity of research exploring the effective strategies that disaster responders can employ to fully leverage social media data [6] [7] [8]. This knowledge gap may arise from an insufficient understanding of the different affordances and functionalities of social media platforms.

To address the existing knowledge gap, the following questions will be examined:

1. How can data be collected from social media platforms for disaster management purposes without relying on APIs?
2. What valuable insights can be obtained from the collected social media data in the context of disaster management?

To answer the research questions, we used a qualitative methodology employing an inductive approach to gather and analyze data from officers working in disaster management organizations (DMOs). By embracing this method, significant themes and patterns surfaced and underwent thorough scrutiny, ultimately leading to the extraction of the research outcomes.

The paper is organized as follows. In the first section, an overview is presented regarding the use of social media in the context of disaster management, emphasizing the need for additional research in this field. The subsequent sections provide a discussion on disaster management and current research in the area. This is followed by a presentation of our research methodology, describing the techniques employed for data analysis, and the resulting outcomes derived from the analysis. Finally, the paper

concludes by summarizing the study, discussing its implications, and offering suggestions for future research directions.

2 Framing Disaster Management

A disaster is "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources" [9] (p.9). Figure 1 illustrates the general classification of disaster management into four categories, often occurring in a cycle or phases. These categories include mitigation, preparedness, response, and recovery. The classification of disaster management into these categories was originally introduced by FEMA [10] and has been consistently referenced in the literature (e.g., Ngamassi, Ramakrishnan, Rahman [3], Safianu, Van Belle [11], Chikoto, Sadiq, Fordyce [12], Islam, Chik [13]).

The initial stage of the disaster management process is known as mitigation. This phase involves examining potential measures that can be implemented to reduce long-term risks to individuals and properties during disasters. The actions and procedures required are carefully planned well in advance of any actual disaster occurrence. The primary objective of activities and processes undertaken in this phase is to safeguard lives and properties while minimizing the potential costs to be incurred throughout the subsequent phases [3] [10]. Examples of actions taken during this phase include public education initiatives and vulnerability analysis.

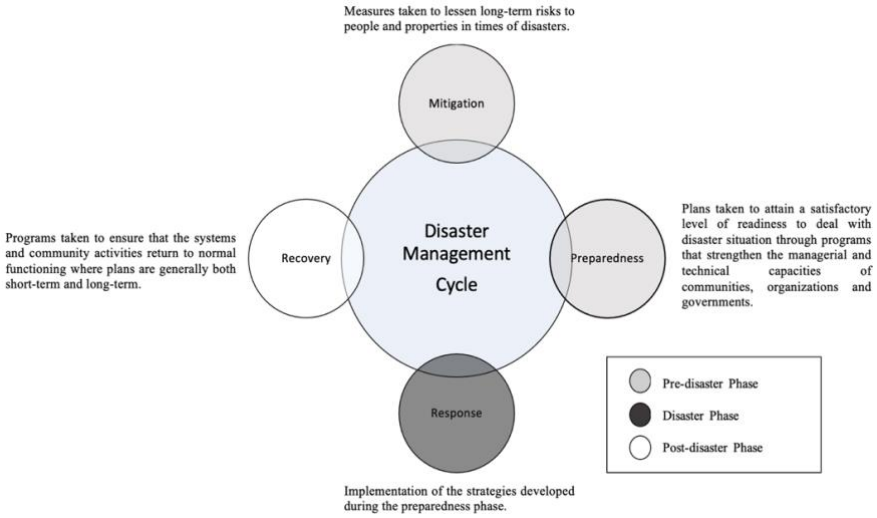

Fig. 1. Phases of disaster management (Safianu, Van Belle [11]).

The second phase in the disaster management process is known as preparedness. As it is virtually impossible to mitigate all potential casualties and risks associated with disasters, it becomes crucial to have a certain level of preparedness in order to minimize their impact [9]. The objective of disaster preparedness plans is to achieve a sufficient level of readiness to effectively handle any disaster situation. This is accomplished

through various programs aimed at enhancing the managerial and technical capabilities of communities, organizations, and governments [14]. These plans serve to evaluate the logistical readiness to respond to disasters by implementing robust procedures and response mechanisms, conducting public education campaigns, developing short-term and long-term strategies, as well as establishing early warning systems. The effectiveness of the preparedness phase hinges on the availability of information regarding hazards, emergency risks, and appropriate countermeasures, as well as the ability of the general public, government agencies, and private organizations to utilize this information effectively [14].

The response phase, which constitutes the third stage of disaster management, comes into play when a disaster is imminent or immediately after its occurrence [10]. This phase primarily involves the execution of strategies formulated during the preparedness phase [3]. It commences with a thorough assessment of the situation and providing aid to victims, as well as restoring critical services such as communication, transportation, and water supply, while ensuring the continuity of vital services like fire and police assistance [3] [10] [15]. The primary objective of this phase is to deliver immediate assistance to sustain life and bolster the morale of affected communities.

The fourth and final phase is known as the recovery phase. Its objective is to facilitate the restoration of systems and community activities to their normal functioning state, wherein plans are typically formulated for both short-term and long-term perspectives [3]. Short-term recovery measures focus on bringing support systems back to minimum operating standards, enhancing the quality of life, initiating reconstruction efforts, improving public information dissemination, promoting safety and health education, and conducting economic impact analyses [14]. Information services and resources play a crucial role in this phase, encompassing data gathering related to rebuilding, as well as documenting and analyzing lessons learned. Overall, the recovery phase furnishes valuable information for effective mitigation and preparedness, thereby reducing vulnerability to future disasters [14].

3 The Research Landscape

The affordability of social media as a communication tool and its ability to enhance management functions have prompted numerous organizations, including DMOs, to incorporate it into their daily operations [16]. The decision to adopt social media can be attributed to the benefits derived from directly reaching a large audience through these platforms [17]. In situations where information is scarce during disasters, people resort to alternative means to satisfy their communication needs, which can potentially give rise to misinformation. During such times, DMOs are perceived as reliable sources of information because they possess the capability to moderate and share accurate information about the ongoing disaster events [17]. Consequently, DMOs bear the responsibility of informing the public throughout such events, and social media serves as an ideal platform for delivering these essential services. In order to be effective during disaster events, DMOs must adapt their communication strategies on social media. Artman et al. [16] propose two concepts for achieving effective communication during such events. The first concept is "dialogical disaster management," which

involves actively monitoring social media posts to adjust the communication strategy based on the content and feedback received. The second concept is "strategic awareness," which emphasizes on the public's understanding of disaster information as well as the disaster itself. Thus, DMOs need to perceive the general public as active participants in co-creating disaster information, rather than solely being passive consumers of information.

A number of researchers have studied how DMOs use social media by investigating their social media communication strategies during disasters [6] [18] [19] [20] [21]. Generally, DMOs use social media services for information sharing, issuing warning signals, requesting specific information from the general public and fighting misinformation and rumors [17] [19] and influencing the behaviour of the public and media during disaster events [18] [21]. Ehnis and Bunker [19] and Potter [22] studied social media use of DMOs and found out that DMOs mainly use social media at the response phase of disaster management. Even then, they use social media for information dissemination only [17] [23] while social media can be deployed for both disaster information dissemination and gathering [24] [25]. The challenge encountered by DMOs is to understand the affordances and capabilities of social and how it can be used for gathering social signals in all phases of disaster management, i.e., mitigation, preparation, response and recovery phases.

Social signals, in the context of social media, refer to the digital traces and indicators of user activities, interactions, sentiments, and behaviors that are expressed and shared on social media platforms [26] [27]. These signals encompass a wide range of data points, including posts, comments, likes, shares, mentions, hashtags, and user-generated content. Social signals are valuable sources of information as they provide insights into the attitudes, opinions, trends, and real-time updates of individuals and communities [27]. The collection of these signals in the context of disaster management plays a crucial role in improving response capabilities, situational awareness, public engagement, and community resilience [27] [28]. By utilizing social signals available on social media platforms, DMOs can efficiently utilize the information to reduce the impact of disasters and provide assistance to affected communities.

The current research on collecting social signals for disaster management is primarily focused on utilizing application programming interfaces (APIs). This approach of using APIs to gather data from social media platforms is valuable, but it also presents a range of challenges that need to be taken into account. The challenge faced in utilizing APIs is the restrictions imposed by social media platforms on data access, as a response to incidents like the 2018 Cambridge Analytica scandal [29]. This event revealed the unauthorized exploitation of Facebook user data, marking the end of the "Data Golden Age" when freed access to social media user data was prevalent [29]. Consequently, many platforms have imposed limitations or even outright bans on data access through APIs. Thus, the extent and regularity of data collection may be impacted, posing challenges in obtaining comprehensive and up-to-date information. In light of this knowledge gap, we put forth a compelling argument in support of non-API approaches for gathering social signals from social media platforms.

4 Data Collection and Methods

To achieve the research goals, we employed a qualitative methodology with an inductive lens. Inductive research is often employed in qualitative research studies where the goal is to develop theories and concepts that emerge from the data itself [30] [31]. This research approach allows for flexibility and adaptability, as it enables researchers to stay open to new ideas and perspectives that may emerge from the data [32]. Inductive research is particularly useful in exploratory studies like this research, where little prior knowledge or theory exists on the subject of inquiry, and the aim is to generate new knowledge and understanding [33].

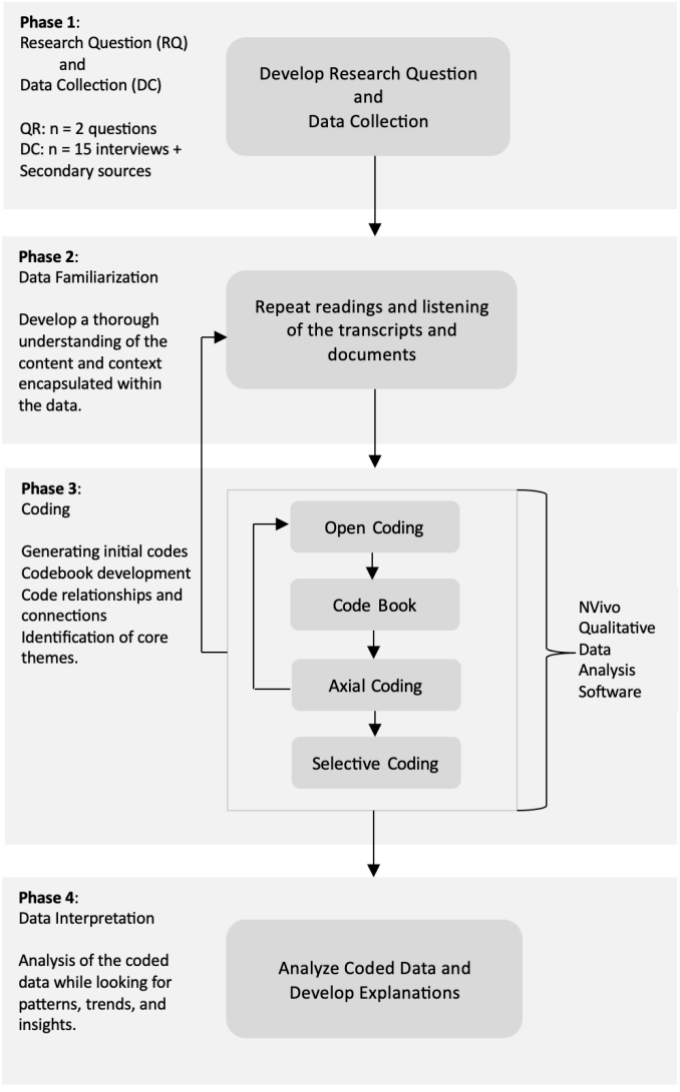

Figure 2. Data Collection and Analysis

4.1 Phases of Data Collection and Analysis

To ensure transparency and replicability in the research, we employed an iterative process consisting of four phases, which are described below and summarized in figure 2. The data was analyzed using the NVivo data analysis tool.

Phase 1: Develop Research Questions and Data Collection

The initial stage involved the development of research questions and data collection focused on exploring the utilization of social signals (data from social media) for disaster management purposes. The research questions can be summarized as follows:

1. How can data be collected from social media platforms for disaster management purposes without relying on APIs?
2. What valuable insights can be obtained from the collected social media data in the context of disaster management?

We gathered data from a total of fifteen (15) individuals affiliated with five (5) disaster management organizations (DMOs) in Ghana using semi-structure interviews. These participants were selected based on their substantial knowledge of the case organizations and their involvement in communication activities on social media. The sample for this study comprised individuals in various positions within the DMOs, including heads of communication units, operations assistants, and research and ICT personnel. These participants were specifically selected to gain insights into how their respective organizations collected data from social media to manage the Accra floods that occurred in 2021. Table 1 presents a breakdown of the participants along with their respective roles or departments.

Phase 2: Data Familiarization

During this phase, we immersed ourselves in the data by engaging in repeated readings and careful listening to the transcripts and documents. This extensive examination allowed us to develop a deep and thorough understanding of the content and context encapsulated within the data.

Phase 3: Coding

Coding is the process of assigning labels or categories to segments of data to facilitate organization, interpretation, and analysis [34]. It involves systematically reviewing the data, identifying patterns, themes, or concepts, and assigning descriptive codes to those segments [35]. This phase involved four stages as follows:

1. Open coding: we started the coding process by generating initial codes, also known as open codes, which captured meaning of the data. This involved examining the data line-by-line and assigning descriptive labels to different segments of the data.
2. Codebook development: As the coding progresses, we developed a codebook which served as a guide that defined and described the codes and their meanings. It provided clarity and consistency in the coding process.
3. Axial coding: After generating initial codes, we looked for relationships and connections between different codes which involved reorganizing codes to create a more comprehensive coding structure in order to identify broader themes that captured these relationships.

4. Selective coding: In this stage, we focused on identifying the core themes that emerged from the data by refining the codes and categories to capture the most significant findings. The goal here was to develop a more concise and meaningful representation of the data.

Phase 4: Data Interpretation
Finally, we interpreted and analyzed the coded data, looking for patterns, trends, and insights. This involved comparing and contrasting different categories, examining relationships between themes, and developing explanations based on the findings.

Table 1. Overview of interview participants and their organizations.

DMO	Function	Informant/Department	Participants
A	An overarching entity responsible for coordinating all disaster events.	Head of Communications Communications Assistant Operations Assistant	1 1 1
B	Responsible for fire events as well as responding to the consequences of storm and flood events.	Research and ICT Operations Public Relations	1 1 1
C	Responsible for health events	Health Communications Advocacy and Social Mobilization Research and Health Policy	1 1 1
D	Environment protection and responsible for all hazards.	Operations General Services	1 2
E	Protection of live and properties	Intelligence Directorate Communications Department	2 1
		Total	15

5 Findings

The following section presents the key findings derived from the analysis of the collected data.

The abundance of data on social media presents a valuable opportunity for DMOs to gather data and analyze information related to disaster events. The analysis of themes conducted in this study, as presented in table 2, revealed that the DMOs actively monitored social media platforms to gather data during the Accra floods in 2021 as stated by an officer from DMO B:

> *"…*the public's information plays a crucial role in guiding our steps, as they are often the first point of contact during disasters. One of our primary tasks was to determine the location of the floods, which we typically infer through interactions with the public on social media. In some cases, they went beyond by sharing eyewitness photos and videos of the damages, and

> they also report specific details such as flood locations, road closures, or power outages.*"* — Officer 1, EDMO B.

Disaster management is commonly divided into four distinct phases: mitigation, preparedness, response, and recovery [3] [10]. These phases often form a cyclical pattern, with mitigation and preparedness serving as the pre-disaster stage, the response phase as the disaster stage, and the recovery phase as the post-disaster stage [11]. During the mitigation phase, efforts are focused on reducing vulnerabilities and risks associated with disasters. This includes gathering data to identify and assess potential hazards and develop effective mitigation strategies. Data analysis revealed that the DMOs prioritize mitigation activities during the floods, particularly on platforms like Facebook and Twitter. An officer from DMO D emphasized the importance of these efforts:

> "Our approach to handling the floods included a comprehensive perspective, lasting the entire duration from the initial stages to the final stages. When we anticipate the occurrence of floods, we conducted risk assessments, which involved monitoring conversations on Facebook and Twitter to gather data on potential risks to determine their potential consequences." — Officer 3, DMO D.

Table 2. Social Signals for Disaster Management

Disaster Phase	**Themes/Social Signals**
Mitigation	• Monitoring Conversions
Analysis of Potential Measures and Risks	• Potential Risks • Potential Consequences
Preparedness	• Understanding Public Sentiments
Evaluation of Logistical Readiness	• Emerging Trends • Identifying Vulnerable Communities • Identification of Stakeholders
Response	• #Hashtags use for Information Gathering
Delivery of immediate Assistance	• Determination of Disaster Location • Requests for Assistance • Witness Account • Survivor Requirements
Recovery	• Recovery Requirements
Reconstructions and Restoration of life and Systems	• Information on Donations • Appeal for Contribution • Public Sentiments on Services • Offers of Assistance from the Public

Data analysis also showed that the DMOs clearly engage in data gathering activities in the preparedness phase of disaster management, which proved valuable in understanding public sentiment and emerging trends related to the floods. In this phase, DMO B emphasized the significance of identifying communities facing resource shortages through social media:

> "While predicting the exact timing of floods proved challenging, we managed to create compilations of potential scenarios by analyzing past floods and their outcomes. With the assistance of platforms such as Facebook, Twitter, and websites of government agencies like the interior

> ministry and ministry of information, we utilized environmental and societal data to understand the local community better. In the case of the 2021 floods in Accra, we were able to anticipate their occurrence and assess their impacts by examining relevant data on social media. This enabled us to identify communities that may face limited access to specific resources." — Officer 2, DMO B.

Data analysis also showed that identification of stakeholders for disaster management can also be derived from social media data, particularly during the preparedness phase:

> "...Facebook played a critical role in the identification of multiple stakeholders when news of the floods was developing. These stakeholders included news and media organizations, government agencies and officials, business entities, and affected communities. This valuable insight facilitated the development of a response strategy that catered to the distinct requirements and concerns of each group. Moreover, it enabled personalized communication with these stakeholders, ensuring the effective dissemination of pertinent and tailored information." — Officer 1, DMO E.

The response phase is dedicated to providing critical assistance to save lives and uplift affected communities in times of disasters. Its primary aim is to deliver immediate aid, including first aid, food, water, clothing, search and rescue operations, and the evacuation of impacted individuals. This phase assumes a critical role in addressing the immediate needs of affected individuals, prioritizing their safety, and mitigating the impact of the disaster. During the response phase of disaster management, the DMOs were highly active, resulting in extensive collection of social signals on social media platforms. For example, an officer from DMO A stated:

> "...we implemented a coordinated strategy by urging the public to share details of damages on Twitter and Facebook using specific hashtags. This approach successfully consolidated the messages, resulting in a powerful and efficient method of collecting and distributing information within the community." — Officer 2, DMO A.

An officer from DMO C added by stating,

> "To swiftly identify flood-affected areas, we conducted a thorough analysis of images, messages, and requests for assistance on social media. The collection of such real-time information proves immensely valuable as it allows us to promptly deploy officers to the identified locations." Officer 1, EDMO C.

During this phase social media platforms serve as convenient avenues for disseminating and accessing crucial information during emergencies and disasters, as confirmed by an official from DMO B:

> "During the floods in Accra, social media platforms like Facebook, TikTok, and Twitter played a crucial role in facilitating our response efforts. These platforms were utilized by individuals to share valuable information, often sourced directly from witnesses on the ground. This information was made up of a wide range of critical details, such as reports on injured and deceased individuals, urgent requirements of those affected, updates on missing persons, and accounts of individuals who were found.

> Notably, these channels not only provided eyewitness information but also delivered news about the floods much faster compared to traditional mediums like television and radio." Officer 2, DMO B

The concept of crowdsourcing, which refers to harnessing the collective strength of individuals via social media to aid disaster response, has demonstrated success in numerous scenarios. The actions undertaken by the DMOs on social media, as described earlier, can essentially be categorized as crowdsourcing. However, an explicit reference to crowdsourcing was made by an official from DMO D who stated:

> "... in the context of disaster planning and response, the accessibility and effective management of data hold immense significance. During the Accra floods, we encountered notable challenges concerning coordination and the availability of real-time information. To tackle these obstacles, we harnessed crowdsourced data obtained from platforms such as Twitter, Facebook, and TikTok, tapping into the collective wisdom of the public, including both victims and volunteers present at the disaster site. This crowdsourced data played a big role in bridging the information gap and equipping our officers with real-time, context-specific information in flood-affected areas, where conditions and needs were continuously evolving. Furthermore, it enabled us to capture direct feedback, often overlooked by other sources of information." Officer 3, DMO D

During the recovery phase, which represents the fourth stage of disaster management, the DMOs extensively employed crowdsourcing as well. As described by an officer from DMO A, data obtained from social media played a crucial role in identifying the allocation of relief supplies during the recovery phase:

> "...following the subsiding of floodwaters, social media emerged as a vital tool in facilitating aid donations and financial support. The fast-paced and interactive nature of social media platforms not only allowed us to appeal for contributions from local and global sources, but also facilitated the swift and effective delivery of aid, addressing the immediate recovery requirements of the disaster-affected individuals. In particular, Facebook data played a key role in identifying the geographic distribution of relief supplies during the initial phases of post-flood recovery, significantly aiding our relief logistics endeavors..." Officer 1, DMO A.

In a similar vein, DMO D leveraged the power of crowdsourcing to uncover requests for essential services during the recovery phase. This was highlighted by an officer from DMO D:

> "After our prompt response to distress calls during the floods, social media played a vital role in evaluating the progress of recovery within the affected community. By analyzing the connection between online discussions and the actual activities of those impacted, we obtained valuable insights. In particular, Facebook data proved beneficial in identifying requests for crucial items like shelter, financial aid, volunteer help, clothing, and medical supplies. Furthermore, it allowed us to connect these requests with offers of assistance conveyed through social media platforms." Officer 1, DMO D.

Of particular interest, DMO B utilized a portion of the recovery phase to gather data from Facebook, Twitter, and Instagram, aiming to gain insights into the public

sentiments concerning their services. This approach was confirmed by an officer from DMO B:

> "After the floodwaters subsided and relief operations commenced, people turned to Twitter, Facebook, and TikTok to voice their grievances. They utilized these channels to bring attention to our shortcomings, including disparities in the distribution of aid among flood victims. We actively monitored the communication and sentiments expressed on these platforms to identify any discordance between the public and our organization. Recognizing that such discordance could hinder the overall recovery process from the floods, we sought to address these concerns and improve our response accordingly." Officer 2, DMO B.

Data analysis has revealed the widespread utilization of social media platforms by all the DMOs for the purposes of gathering social signals across various stages of disaster management. The dataset derived from social media has proven to be an invaluable resource in informing decision-making processes and enhancing situational awareness. The abundance of information obtained from these platforms has provided valuable insights into the needs and issues surrounding the floods. This, in turn, has enabled DMOs to assess the impact of the floods, monitor the progress of recovery efforts, and identify areas or gaps requiring immediate attention.

6 Discussions

The study's results suggest that collecting social signals on social media platforms can be achieved through methods other than relying solely on APIs. Although APIs provide direct access to data from social media platforms, they have limitations in terms of accessibility and analysis. The study has showcased the efficiency of alternative approaches in gathering and analyzing publicly accessible information on these platforms, which will be discussed further below.

6.1 Harnessing Social Media Data for Disaster Management

The study shows that social signals can be efficiently collected from social media platforms without relying on APIs. These social signals, obtained through alternative methods, hold significant potential for enhancing decision-making processes across different phases of disaster management. During the mitigation phase of disaster management, monitoring social signals can enable the identification and evaluation of potential hazards associated with disasters, facilitating the development of effective mitigation strategies. Additionally, social signals can be utilized to assess the risks posed to human life and infrastructure as a result of disasters. By integrating social signals into the decision-making process, stakeholders can enhance their understanding of the challenges posed by disasters and take proactive measures to minimize their impact.

During the preparedness phase, the utilization of social media data can facilitate the identification of communities experiencing resource shortages. This valuable information enables the targeted distribution of supplies and aid to areas that are most in need, while also aiding in the identification of stakeholders involved in disaster management. By incorporating social media data into preparedness strategies, decision-

makers can enhance their ability to address community needs and optimize resource allocation in the face of potential disasters.

In the response phase of disaster management, which is the third stage, the gathering of social signals assumes a vital role in identifying and comprehending the dynamics of disaster situations, along with assessing their severity. In this phase, crowdsourcing plays a significant role in facilitating data collection from the general public. The information derived from social signals and crowdsourcing plays a crucial role in accurately evaluating the magnitude of the incident, the extent of damage incurred, and the urgent assistance needed to save lives and address the immediate needs of affected individuals. By leveraging social signals and crowdsourced data, decision-makers can accurately evaluate the scale of the incident, the extent of damage incurred, and the urgent assistance needed to address the immediate needs of affected individuals. This collaborative approach contributes to saving lives and expediting the recovery process.

In the fourth and final stage, the recovery phase, crowdsourcing can be effectively utilized to identify requests for essential services. This includes needs for shelter, financial aid, volunteer assistance, clothing, and medical supplies. Additionally, the collection of social signals in the recovery phase can provide valuable insights into public sentiments regarding the services provided throughout the entire process facilitating continuous improvement and ensuring public satisfaction. By leveraging crowdsourcing and social signals, decision-makers can enhance the effectiveness of the recovery phase and contribute to the successful restoration and rebuilding of affected communities.

The research demonstrates that it is possible to efficiently gather social signals from social media platforms without exclusively relying on APIs as the primary data source. This innovative approach to collecting social signals through alternative methods holds considerable promise for bolstering decision-making procedures throughout various stages of disaster management. During the mitigation phase of disaster management, the capability to monitor social signals emerges as a crucial asset. These signals provide insights that facilitate the identification and assessment of potential hazards associated with impending disasters. This, in turn, empowers authorities to develop and implement effective mitigation strategies to reduce the impact of such hazards. As highlighted by Smith and Wenger in their work on environmental hazards, the utilization of social signals from platforms like social media can greatly enhance hazard assessment and improve the overall disaster management framework [36]. Furthermore, the integration of social signals into decision-making processes proves instrumental in evaluating the risks posed to both human life and critical infrastructure in the aftermath of disasters. This aligns with the findings of a study by Castillo et al., which emphasize the utility of social media data in real-time disaster impact assessment and resource allocation [37]. By harnessing the potential of social signals, stakeholders can refine their understanding of the multifaceted challenges presented by disasters, enabling them to proactively devise strategies to mitigate these challenges and minimize their repercussions.

6.2 The Value of Social Media Data for Disaster Management

The study reveals that monitoring and gathering social signals plays a crucial role in disaster management. By analyzing user-generated content and interactions on social media platforms, potential hazards related to disasters can be identified in a timely manner. These social signals provide valuable insights into emerging risks, such as geographical areas prone to specific hazards or patterns indicating the likelihood of certain disaster events. Social signals can also be used to assess the potential risks of loss of life and destruction caused by disasters. By monitoring social media data, decision-makers can gather information on the vulnerabilities and exposure of communities to hazards. This includes understanding the demographics, infrastructural weaknesses, and socio-economic factors that may exacerbate the impacts of disasters. By leveraging social signals, the evaluation of the severity and potential consequences of a disaster is simplified, enabling the prioritization of mitigation efforts effectively. This information empowers DMOs to allocate resources, implement targeted interventions, and develop mitigation strategies tailored to the specific risks faced by communities.

The importance of harnessing social media data cannot be overstated. By analyzing user-generated content and patterns on social media platforms, DMOs can identify communities that are facing resource shortages. This information allows for a more precise allocation of supplies and aid, ensuring that the areas with the greatest need receive the necessary assistance. Moreover, social media data or signals can play a vital role in identifying stakeholders involved in disaster management, fostering a more comprehensive and inclusive approach to disaster management.

The study emphasizes the importance of collecting social signals, particularly through crowdsourcing. By engaging the general public in data collection efforts, DMOs can access a wealth of real-time information and insights about the ongoing disaster. This collective knowledge helps in identifying affected areas, understanding the evolving nature of the disaster, and comprehending its impact on the population. Again, monitoring social media platforms and analyzing user-generated content is significant in gaining valuable information about the public sentiments and experiences related to the services rendered throughout the entire disaster management process. This feedback aids in evaluating the effectiveness and impact of the provided services, highlighting areas of improvement and identifying success stories. It also helps in gauging public satisfaction and addressing any ongoing concerns or challenges

7 Conclusion, Implications, and Future Research

The study brings attention to the possibility of collecting social media signals without solely relying on APIs. While APIs offer direct access to social media data, they have limitations in terms of accessibility and analysis. However, the study successfully demonstrates the effectiveness of alternative methods for gathering and analyzing publicly available information on these platforms. It highlights the importance of considering accessibility in data collection. While APIs provide direct access to specific information, they often have limitations such as restricted access to certain data types or limited availability of critical data. By diversifying data collection approaches, both DMOs and researchers can create more comprehensive datasets for analysis. These social signals, obtained through alternative methods, have immense potential for

enhancing decision-making throughout various phases of disaster management. By employing innovative approaches and techniques, DMOs can tap into the wealth of social signals present in public posts, comments, and interactions. These signals encompass user sentiments, opinions, and real-time updates, offering valuable insights that greatly assist decision-making during different stages of disaster management. Additionally, the study underscores the usefulness of social signals across various phases of disaster management. From early warning and preparedness to response, recovery, and mitigation, social signals sourced from social media can inform decision-making at each step. They aid in identifying potential hazards, assessing the impact of disasters, monitoring response effectiveness, and evaluating long-term recovery processes. Overall, the study emphasizes the effectiveness of gathering social signals from social media platforms without relying solely on APIs. It highlights the potential of these signals in improving decision-making throughout different stages of disaster management. By incorporating social media data and utilizing alternative methods, decision-makers can enhance situational awareness, response strategies, and overall outcomes in disaster management.

One limitation of this study is the potential bias in the data collection process. Since the qualitative methodology relies on input from officers working in disaster management organizations (DMOs), the findings might be influenced by the perspectives, experiences, and opinions of these individuals. Their viewpoints could introduce subjectivity and specific organizational biases that might not fully represent the broader landscape of disaster management practices. Additionally, while the study underscores the potential benefits of gathering social signals through non-API methods, it might not fully address the technical complexities and ethical considerations involved. These non-API approaches could introduce challenges related to data privacy, security, and the reliability of the collected information. These aspects warrant further exploration and discussion to ensure that the utilization of social signals remains ethical, legal, and accurate.

Based on the findings and implications of the study, there are several potential future research directions that can be explored including:

1. Privacy and Ethical Considerations: As social media data collection and analysis involve personal information; future research should delve into the ethical and privacy implications of utilizing such data for disaster management. This includes exploring methods for anonymization, informed consent, and ensuring data security and privacy protection.
2. Long-Term Impact and Recovery: Further investigation can be conducted on the long-term impact of disasters and the role of social media data in the recovery and resilience-building process. This includes assessing the effectiveness of recovery efforts, evaluating community perceptions, and exploring how social signals can contribute to long-term planning and resource allocation.
3. Comparative Studies and Benchmarking: Future research can conduct comparative studies and benchmarking exercises to assess the performance of different data collection methods and analysis techniques. This can help identify best practices, standardize methodologies, and establish benchmarks for evaluating the quality and reliability of social media data in disaster management.

By exploring these research directions, scholars and practitioners can continue to advance the field of utilizing social media data for disaster management, leading to

improved decision-making, more efficient responses, and enhanced community resilience.

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