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Social media use in disaster response: empowering community resilience

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ABSTRACT

This article contributes to ongoing discussions on the role of grassroots mobilizations on social media in building community resilience and tackling specific challenges during disaster events. It investigates the use of two social media platforms, Facebook and Twitter, now referred to as X, during the 2021 flood in Belgium, both in the immediate aftermath of the crisis and in the short-term. First, it analyzes the activities of Facebook community groups established post-crisis over a six-month period. Then, it examines tweets related to the 2021 flood in Belgium. Finally, it complements the social media data with online interviews conducted with Facebook groups administrators. The analytical framework employs (1) a social media data-driven quantitative and qualitative text analysis using topic modeling and sentiment analysis, and (2) an inductive thematic analysis of interviews. The findings highlight the different roles played by the two social media platforms. Facebook served as an effective platform to mobilize and organize local communities for immediate and practical support, while Twitter served as a platform for broader global engagement and advocacy. The convergence of results from diverse data sources provides comprehensive insights into the effectiveness and challenges of leveraging social media for community resilience in the aftermath of disaster events.

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Crisis response; community resilience; grassroots mobilization; social media; Facebook groups; topic modeling

1. Introduction

The United Nations Office for Disaster Risk Reduction (UNDRR) reports that the number of recorded disasters has increased fivefold over the past 50 years, largely due to human-induced climate change, significantly challenging disaster prevention and mitigation efforts (United Nations 2023). Among extreme natural hazards, floods are particularly widespread and are expected to increase in frequency and occurrence (Goodess 2013; Tradowsky et al. 2023). In July 2021, the low-pressure system 'Bernd' brought heavy precipitation, resulting in severe flooding in the Walloon region of Belgium. This flood was the most devastating in Belgium's history, causing 39 fatalities,

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over 700 injuries, and widespread damage to homes, businesses, and infrastructure (Lietaer et al. 2024). Hundreds of buildings were destroyed, and thousands more suffered significant structural damage, leading to extensive intangible damages (Dewals et al. 2021). More than 200 bridges, railway tracks, and kilometers of gas, drinking water, and electricity supply networks were destroyed (Dewals et al. 2021).

The event exposed a lack of preparedness and well-established proactive measures, leaving the community unprepared to respond (Lietaer et al. 2024). Moreover, Belgian authorities and emergency responders faced significant challenges in coordinating relief efforts, governing, and managing the impacts of the flood during the disaster and in its aftermath (Lietaer et al. 2024). In this context, social media emerged as a valuable tool for enhancing situational awareness and supporting post-disaster management (LEMA 2021).

During such disastrous events, there is often a remarkable surge in the use of social media platforms (Karimiziarani et al. 2023; Mihunov et al. 2020). Social media has become integral to emergency responses and building resilience, leveraging timely information exchange and providing vital social support through digital connectedness among users (Xie, Pinto, and Zhong 2022). Social media has received considerable attention from researchers in risk and crisis communication and management (Kamara 2016; Rasmussen and Ihlen 2017). Among the various investigated aspects of social media usage during disasters is its effective role in building and enhancing resilience (Mihunov et al. 2020; Xie, Pinto, and Zhong 2022). Amid arguments mentioned in the literature are the ability of social media to (1) facilitate information sharing while engaging in dialogs and building relationships, (2) enable real-time coordination at the grassroots level, (3) empower communities to develop and use emergency responses to mitigate crisis outcomes, and (4) support rescue operations (Eriksson 2018b; Mihunov et al. 2020; Rasmussen and Ihlen 2017; Xu and Wu 2015). Yates and Paquette (2010, 2) suggest that disaster response serves as the ideal environment for 'proving the worth' of social media as a significant knowledge management platform.

This study aims to contribute to this ongoing scholarly discussion by examining how social media facilitates grassroots mobilizations that support community building and resilience during the immediate aftermath and recovery phase of a disaster. While much existing research on social media in disaster management has focused on the early phases of the disaster response process, typically through quantitative analyses of public discourse on Twitter (Eriksson 2018a; Ogie et al. 2022; Rasmussen and Ihlen 2017), there is a limited number of qualitative studies on how online mobilization efforts translate into real-world collective support and action that foster community resilience during the recovery phase. This paper seeks to fill this gap by investigating the use of two social media platforms, Facebook and Twitter, currently referred to by X, in facilitating grassroots mobilizations during the 2021 flood event in the Vesdre Valley, Belgium. The research question guiding this study is as follows: In what ways do social media-facilitated grassroots mobilizations support the development of community resilience during the disaster recovery phase? To answer our research question, we apply a methodological framework that integrates multiple data sources. First, we examine Facebook community group pages that were initiated in response to the flood hazard and their activities for a six-month period after the crisis. Then, we investigate tweets related to the 2021 flood in Belgium. Subsequently, we complement social media data with open-ended online interviews with Facebook groups administrators.

In the following, we address the use of social media during crises then we expand on the idea of how social media contributes to community resilience. Afterwards, we present the methodological framework followed by a discussion of the main findings and their implications.

2. The use of social media during crisis

The crisis cycle comprises three major phases: pre-crisis, crisis and post-crisis. During the crisis phase, the initial response stage is marked by an influx of protective messages and situational updates (Villodre and Criado 2020). This phase demands decisive and cooperative actions, often involving the amplification of key messages. Social media increasingly serves as a significant source and distributor of information during this phase, providing rapid and immediate assistance or timely updates (Wang et al. 2016a; Xu et al. 2017). The crisis and post-crisis phases can be divided into the acute phase of the crisis (lasting from days to about two weeks), emergency response and early recovery, which involve immediate reactions, cleaning, relocation, provision food and services, preliminary insurance and administrative contacts, and restoration of basic functions (lasting from days to about three months), short-term recovery, focusing on the restoration of lifeline systems and decision-making leading to subsequent actions (lasting from three months to about two years), and longer-term recovery and reconstruction (lasting from two to about 10 years) (NRC 2006; Oulahen, Vogel, and Gouett-Hanna 2020). The timeline for recovery varies significantly depending on the context, and the pace of recovery differs among those impacted by disasters or various types of impacts (NRC 2006). Social media data analytics can prove valuable in understanding emergency response during the immediate aftermath and short-term recovery stages (Qadir et al. 2016).

The widespread use of social media platforms during disasters has been accompanied by extensive research on the various aspects of their usage. For example, Keim and Noji (2011) highlighted the role of social media in disaster management during the world response to the 2010 Haiti earthquake. Social media became the new forum for collective intelligence, social convergence, and community activism as millions joined MySpace and Facebook discussion groups to share information, donate money, and offer comfort and support (Keim and Noji 2011). In alignment with this research, Ambinder and Jennings (2013) explored the potential role of social media in supporting community resilience through the case of #OccupySandy. Their findings revealed various roles of social media during the crisis, such as serving as the main platform to attract and mobilize a significant volunteer force, coordinate rapid relief services, identify real-time community needs, and share information (Ambinder and Jennings 2013). In parallel, different investigations have delved into the prospect of using social media data to gain insights into communities' behaviors and responses during crises. For instance, Collier and Collier (2013) tracked crowd responses on Twitter to identify opinions and emotions during different earthquake situations and provide valuable situational awareness. In addition, Kryvasheyeu et al. (2016) explored how social media enables real-time communication amid disasters, while Wang, Ye, and Tsou (2016b) examined its role in discussing situational updates and damages during such events. Other studies conducted response analysis during disasters analyzing social media expressions (Deng et al. 2018). Aligning with this body of research, Li et al. (2019) conducted semi-

structured interviews of 15 people who were rescued during Hurricane Harvey to explore the psychological dimensions of social media use amid the disaster. Their findings revealed that users engaged in sharing instrumental and emotional support (Li et al. 2019). More recently, Karimiziarani et al. (2023) examined the textual content of users' posts shared on Twitter across the 48 contiguous U.S. states to provide insights into the social response to hurricanes and assist crisis management agencies and disaster responders during and post disasters.

Other inquiries have employed social media and digital narratives as a tool for participatory resilience planning and for engaging different community groups in building their communities and their resilience to climate change (Napawan, Simpson, and Snyder 2017). In this framework, Dufty (2012) argues that social media can easily form 'communities of practice', which can contribute to building community disaster resilience before, during and after an event. In accordance with Wenger, McDermott, and Snyder (2002, 4), these communities of practice are defined as 'groups of people who share a concern or passion for something they do and learn how to do it better as they interact regularly'. In line with this argument, White (2011, 187) states that 'community resilience should include a grassroots effort where social media is utilized in a number of ways to support the safety of the community.' Yuan et al. (2021) argue that building a knowledge of public sentiment and concerns during disasters through the lens of social media users can reflect some aspects of the dynamic interactions among citizens, disasters, and the built environment and hence further enhance the understanding of disaster resilience.

These studies suggest that the use of social media during disaster events has the potential to facilitate effective response, enhance risk reduction, and support understanding of citizens' behaviors and responses during disasters (Kryvasheyeu et al. 2016; Pourebrahim et al. 2019). However, despite a growing body of research examining the use of social media during emergencies, the majority of studies predominantly rely on Twitter as their primary data source. There is less work that integrates data from multiple social media platforms and complements it with traditional data sources such as surveys and questionnaires to provide a more comprehensive interpretation of results. This paper seeks to explore the implications of digitally mediated grassroots mobilization in times of disaster events and its impact on community disaster resilience.

3. Social media contribution to community disaster resilience

Borrowing from the field of ecology, *resilience* refers to the capacity of a system – which encompasses social, political, and cultural systems such as communities, cities, or regions – to respond to change and disruption while still maintaining its fundamental function, structure, form, and identity (Amundsen 2012). Expanding on this broad definition, *social resilience* refers to the 'capacity of social groups and communities to recover from, or respond positively to, crises' (Maguire and Hagan 2007, 16). Recent disaster studies have emphasized the importance of understanding the social aspects of resilience in the face of disaster events (Cutter, Ash, and Emrich 2016). This knowledge is invaluable for disaster management agencies, assisting them in effectively gathering data on disaster situations and enabling the implementation of more effective response strategies (Yuan and Liu 2020).

Compared with traditional communication channels (e.g. radio, television, and newspapers), social media offers a participatory and collaborative structure and collective knowledge-building capacity for public information and warning approaches (Zhang et al. 2019). Social media operates on peer-to-peer networks characterized by collaboration, decentralization, and community-driven interactions (Keim and Noji 2011) and thus inherently has the potential to build emergency management communities of interest that share responsibilities (Dufty 2012). Recent studies have explored the role of social media in fostering social and community resilience. Reuter and Spielhofer (2017) interviewed 1034 citizens across 30 European countries to explore citizens' attitudes towards the use of social media in emergency situations and argued that social media plays a pivotal role in promoting social resilience. Hong et al. (2018) examined how community disaster resilience and social solidarity concerning the 2014 Sewol ferry disaster in South Korea were portrayed on and manifested by social media.

In the realm of social sciences, there is a widespread recognition that individuals demonstrate self-resilience during and in the aftermath of crises (Jurgens and Helsloot 2018; Scanlon, Helsloot, and Groenendaal 2014). Under the self-resilience concept, disaster management and recovery processes do not solely rely on the government but are also dependent on individuals and their empowerment (Oloruntoba and Asare-Doku 2021). Self-resilience relies mainly on people getting together around the site of the disaster, whether geographically or virtually, to share resources and support (Naumann, Rampp, and Endreß 2019). Jurgens and Helsloot (2018) provide insights into the influence of social media on the possibilities for and practices of self-resilience. They delve into four elements of self-resilience – information gathering, information dissemination, collaborative problem-solving, and coping – to understand how they are affected by the use of social media. Jurgens and Helsloot (2018) argue that the self-resilience of affected citizens can be supported not only by those present at the scene but also by anyone with internet access. The increased information exchange enables affected citizens to collaborate in problem-solving, enhancing their resilience and making them more capable of dealing with the situation independently.

In accordance with the concept of self-resilience, community resilience describes the collective ability of groups of people to deal with stressors and collectively access and exhibit resources through cooperation (Frounfelker et al. 2020). It is a process wherein groups of individuals collectively access and utilize resources that allow them to attain positive outcomes in the presence of uncertainty and stress (Aldrich and Meyer 2015). Community resilience is often perceived as a more positive and proactive expression of individual and community engagement with natural hazard reduction (Cutter et al. 2008, 598). In a systematic review on community resilience, Patel et al. (2017) identified 75 unique definitions of community disaster resilience. Even though the concept of community resilience is amorphous and understood differently by diverse research groups, nine main themes appear important (Patel et al. 2017), i.e. local knowledge, community networks and relationships, communication, governance/leadership, health, resources, economic investment, preparedness, and mental outlook. Digital technologies provide invaluable tools for facilitating collaboration within groups, with social media platforms serving as critical arenas that foster community resilience practices within the digital sphere (Udwan, Leurs, and Alencar 2020).

Through a case study of the 2011 earthquake in Japan, Kaigo (2012) highlighted the important role of social media, given that power outages did not allow the usage of traditional media and interrupted internet access through personal computers limited people's connectivity. In this situation, smartphones became the primary devices for media access and communication after the earthquake (Kaigo 2012). It should be highlighted that researchers have found that during disaster events, relevant tweets mostly provide information about the event and its impacts, rather than the risk information the public expects to receive through alert messages (Liu et al. 2019). Recently, Lam et al. (2023) outlined four significant contributions of social media data for disaster resilience research and management, encompassing serving as an effective communication platform, providing ground truth information for emergency response and rescue operations, offering information on people's sentiments, and allowing predictive modeling. In addition, they highlighted four primary challenges associated with its use, including the rapid dissemination of false information, disparities in social and geographical usage patterns on platforms like Twitter, technical issues when processing and analyzing big and noisy datasets, and biases inherent in algorithms utilized in artificial intelligence (AI) and other types of modeling (Lam et al. 2023).

Research has shown that the use of social media in disaster contexts is wide-ranging, from receiving disaster preparedness information and warnings to detecting and signaling disasters before they occur, as well as reconnecting community members following a disaster (Houston et al. 2015). These uses can operate at multiple levels and involve various user groups, each with distinct purposes (Houston et al. 2015). A recent review emphasizes social media's multifaceted contributions to recovery, including raising awareness, facilitating donations, fostering solidarity, supporting post-disaster reconstruction, disseminating information, and offering mental health support (Ogie et al. 2022). Social media platforms provide recovery managers with valuable insights into business reopening, cleanup efforts, re-entry procedures, infrastructure restoration, donations, fundraising, and volunteer activities (Huang and Xiao 2015). In light of these diverse contributions, Shibuya (2017) proposed a comprehensive framework for analyzing social media data during recovery phases. This framework includes content analysis of topics discussed and conducting sentiment analysis to assess public mood and emotions.

The advantage of social media data is that they are timely providing insights into people's behavior and response to crises at the time of their occurrence. Conventional survey methods rely more on affected citizens' memories of their responses during crisis events. The integration of multiple data sources can provide a more precise and reliable narrative of the use of social media during the crisis and its role in building the community and enhancing its short-term resilience. We apply a time frame of approximately six months to the analysis of social media data, looking at the acute phase of the crisis (two-week period), followed by emergency response and early recovery (two-month period), followed by early reconstruction stage (three-month period).

4. Methodological framework

4.1. Data collection and pre-processing

To explore how people use social media during the flood, we first identified relevant Facebook groups and analyzed their activities over a six-month period. Then, we

examined tweets related to the 2021 flood in Belgium. Finally, we complemented the social media data with online interviews conducted with Facebook groups administrators. We examined 4 Facebook public groups that were initiated in response to the crisis and were actively engaged in mobilizing community members and 2 Facebook community pages that existed before the crisis and are dedicated to the case study, namely the Vesdre River. To conduct the empirical study, we first interviewed the Facebook administrators. The interviews were conducted between 23 January 2023 and 15 March 2024. Interviewees verbally consented to having their interviews recorded. The questionnaire consisted of five different parts addressing (1) the purpose of social media use during the crisis, (2) the role of social media in building the community and joining efforts to address specific challenges during the crisis, (3) the perceived community support and interaction on social media, (4) the impact of 'online' interactions on 'offline' support, and (5) the role of social media in showcasing community resilience or unity during the crisis. The interviews were conducted online in French; then, *Google Colaboratory* was used to run Whisper AI in Python to transcribe the audio files and translate them into English.

Following this, we proceeded with the scraping and preprocessing of social media data. Employing web data crawling software, we gathered posts from Facebook and Twitter. First, we extracted all posts from five of the addressed Facebook groups and pages. For the sixth group with broad coverage, we used keyword searches to scrape posts. We collected posts along with associated comments, dates, and metrics such as reactions and shares from the period spanning between July 15th, the date of the crisis, and December 31st, which marked the cessation of activity for most Facebook groups involved. The number of scraped posts per page ranged from 43 to 355. The number of members of public groups ranged from 26,500 to 266, and the total number of Facebook pages members varied from 2100 to 163. It is worth mentioning that the aim was not to compare the activities of these groups or the most and least successful ones in mobilizing people but to precisely address the digitally mediated practices in a broad sense and their contribution to building the community and enhancing resilience. Therefore, all 865 posts and 1164 comments from the different groups and pages were combined into one textual database. The following step consisted of running an advanced search in Twitter to scrape tweets with two hashtags combined as follows: '#Belgium' or '#Wallonia' and '#flood' or '#floods' or '#flooding', or '#flood2021'. We looked for posts in English, French, or Dutch. After excluding duplicates and irrelevant posts, the total number of analyzed tweets for the time period between mid-July and December 2021 was 1130, of which 912 were posted between 15 and 31 July. We retrieved all the metadata associated with the tweets, including each user's country and profile.

Facebook posts were in French and Dutch, whereas tweets were also available in English. The textual data were translated into English using the Google Translate function in Google Sheets. The data were converted into a dataframe and then into a corpus using RStudio software. The next step consisted of preprocessing the text corpus using the *tm package* to eliminate punctuations, numbers, stop words, and specific words that did not carry any relevant information for the analysis, while also converting the text to lowercase and stripping white space.

The six-month period following the crisis marked the cessation of activity for most Facebook groups involved in the disaster response. This temporal dimension provides

a demarcation of online community mobilization between the response and short-term recovery phases, since as the recovery phase extends, it typically involves a shift to a different set of actors and priorities (Correia, Água, and Simões-Marques 2021). Despite the decrease in social media activity, the interactions and information shared during the short-term recovery phase leave a lasting impact, feeding into the long-term and sustained recovery efforts (Correia, Água, and Simões-Marques 2023). The feedback gathered through social media can provide valuable insights to support ongoing efforts, contributing to lessons learned for future disaster preparedness and resilience.

4.2. Data processing and analysis

The analytical framework consists of two major stages that complement one another: (1) social media data-driven quantitative and qualitative text analysis using topic modeling and sentiment analysis and (2) thematic qualitative analysis of interviews. The analytical strategies are discussed in separate subsections below.

4.2.1. Social media data topic modeling and sentiment analysis

The first phase involved analyzing the Facebook and Twitter posts separately. Both datasets underwent analysis in RStudio software, employing a consistent analytical method. Initially, the Latent Dirichlet Allocation (LDA) function from the *topicmodels package* was used for topic modeling. LDA is a probabilistic generative model for revealing the underlying semantic structure within a vast corpus of documents (Kherwa and Bansal 2019). This model uses unsupervised machine learning techniques to estimate multinomial observations and has been widely applied for the analysis of social media data during crises (Wahid et al. 2021). This method permits topics to overlap in terms of content, deviating from distinct categorization, thus reflecting the nuanced usage of natural language (Wolff et al. 2020). After identifying the most relevant terms for each topic, in other words, topic keywords, we interpreted the topics with regard to their semantic meaning. In this sense, the LDA function is not employed as an automated tool for analyzing the usage of social media and its contribution to community resilience but rather as a lens through which researchers can engage with the data impartially. Here, subjectivity is transitioned within the methodological framework to the 'post-modeling phase of the analysis,' where interpretation primarily emerges from 'the actual modeling of the data' (Mohr and Bogdanov 2013, 560). To allow more in-depth interpretation of results, we further performed sentiment analysis. Sentiment classification is commonly carried out using machine learning models or lexicon-based methods. Machine learning models are trained using pre-labeled opinion data to predict the sentiment of new instances, whereas lexicon-based methods use predefined dictionaries of sentiment words to classify emotions expressed in the data (Mao, Liu, and Zhang 2024). In recent years, transformer-based models, such as Bidirectional Encoder Representations from Transformers (BERT) and its variant Robustly Optimized BERT Approach (RoBERTa), have revolutionized natural language processing by offering highly effective models for sentiment analysis (Abdal et al. 2023). As advanced Large Language Models (LLMs), these transformer-based architectures excel in processing complex language patterns and capturing intricate contextual information and semantic

nuances in social media data (Abdal et al. 2023). We conducted the sentiment analysis in Python using CardiffNLP, a RoBERTa-based model.

4.2.2. Qualitative analysis of interviews

R-Studio software was employed for the analysis of interviews with Facebook groups administrators. A qualitative thematic analysis was conducted using the *RQDA package* (See Chandra and Shang 2019). The answers to the different questions were coded applying a data-driven inductive approach. Afterwards, codes were connected to identify emerging themes.

5. Results and discussion

5.1. Facebook users' demographics

Four Facebook administrators shared the demographic data of their group members. Results indicate that 96% were from Belgium, with a gender distribution of 55.3% male and 44.7% female. The age distribution of the members was diverse, spanning various age groups: 2% were aged 18–24, 14% were 25–34 years old, 26% were 35–44, 25% were 45–54, 17% were 55–64, and 15% were over 65 years old.

5.2. Facebook posts topic modeling

The Facebook dataset was segmented into six chunks and topic modeling was performed over a span of approximately six months, spanning from mid-July to the end of December, to identify any potential fluctuations in the topics in the immediate aftermath of the crisis and in the short term. Table 1 presents the results obtained.

In July, during the immediate aftermath of the crisis, three topics emerged from Facebook posts. The first two topics related to seeking and offering help:

15 July 2021/User1-"Hello, I'm available if anyone needs help. Good luck to all"

Comment1- "Here is my number […], available day and night to lend a helping hand."

Comment2- "I can also help if you need to move, put in shelter with your animals. I can pick you up if need be. Courage to you"

Comment3- "hello, I have a car and I can help you move if needed, I can also help with decluttering, etc. … I'm on Herstal Feel free"

17 July 2021/User 56– "Good morning ! We are a small group offering our help to clean, bring food, donations of clothing … But we don't know where we would be most useful and especially how to get there?"

19 July 2021/User 89- "Need for volunteers:

[…] which accommodates 50 people needs help on site, the restaurant […] cooked 1000 meals and needs people to help".

15 July 2021/User 7- "You are in NEED, post it here, tell us what you need (cleaning help, material goods, food, housing) in writing here with your municipality. We'll do our best to help everyone"

Table 1. Topic keywords extracted from Facebook posts and their description details.

July Topics	Keywords	Theme
Topic 1	Help, people, center, street, house, contact, available, need, food, please	Help seeking
Topic 2	Donations, cleaning, solidarity, volunteers, courage, people	Offering help
Topic 3	Information, situation, victims, insurance, level, disaster, crisis, affected	Information dissemination and crisis communication
August Topics	Keywords	Theme
Topic 1	Help, food, government, find, house, people	Help seeking
Topic 2	Cleanup, solidarity, volunteers, cleaned, today/tomorrow/ Tuesday/Thursday/Sunday, job, courage, gloves, information	Volunteering, Outreach, and Coordination of cleaning activities
Topic 3	Municipalities, participate, construction, victims	Governance and leadership
September Topics	Keywords	Theme
Topic 1	Gas, collaboration, heating, installation, upgrading, standards	Collaborative problem-solving
Topic 2	Solidarity, citizen, people, together	Solidarity
Topic 3	Volunteers, organization, groups, members, cleaning, Brussels, Antwerp, Dutch	Volunteering, Outreach, and Planning
October Topics	Keywords	Theme
Topic 1	Help/Helping, offer, work, affected, commission, team, people, company, participate, Flemish, Dutch	Offering help
Topic 2	Cleanup, meeting, nature, working, public, organization	Coordination of cleaning activities
November Topics	Keywords	Theme
Topic 1	Help, people, volunteers, victims, courage, home, friends	Endurance
Topic 2	Team, work, construction	Repair/reconstruction
December Topics	Keywords	
Topic 1	Participants, available, help, solidarity, team, Flemish, mission, planning, planting, trees	Planning
Topic 2	Christmas, hope, holidays, courage, forgetting, victims, lives, affected, power, families, give	Memory/Endurance

Comment1- "hello I am looking for a big dehumidifier to dry the walls always wet so I can finally start my work thank you"

Comment2- "Hello, would like to know if you can help with electric heating, I live in Pepinster"

Comment3-"hello I am looking for an electrician and unlucky for a small house. I am desperate thank you"

30 July 2021/User 221-"Hello, following the flooding and the expert's passing yesterday, our house is definitely in total disaster. We are looking for a house or apartment to rent […] Thank you in advance."

The third topic was related to information dissemination and crisis communication.

15 July 2021/User 17-"latest information from the crisis center about the dams in the province of liege […] Some streets have been evacuated in anticipation of the flood peak expected this early afternoon in the Liège region."

16 July 2021/User 41-"For your information, Facebook has launched a crisis service dedicated to the floods in Liège. With a geographically targeted demand/supply system: food, clothing, volunteering, water, transport, animal assistance, etc."

16 July 2021/User 46-"Hello everybody, Here is the information from the crisis center for aid and donations"

17 July 2021/User 61-"Our Mobile Crisis Centers will travel in the next few days to the cities and municipalities hardest hit by #floods. Our experts will assist you report your damages on the spot and you can benefit from an automatic fund advance."

23 July 2021/User145-" […] Mayor of Limbourg, recommends that victims clear the flooded area from tomorrow at 11 a.m […] the mayor does not want to take any risks." Good … very good … 1200 people concerned … .What are the means of evacuation made available to the victims to evacuate and to which places?"

In August and September, during the emergency response and early recovery phase, topics such as volunteering, outreach, and coordination of cleaning activities, governance and leadership, and collaborative problem-solving emerged:

20 August 2021/User 326 "Hello, we need you on Sunday to advance again in cleaning our site […] The river and its wood are filled with waste to be evacuated […]."

25 August 2021/User 402 " We've reached 400 members. I hope to see at least a quarter on Sunday to clean the river."

29 August 2021/User 409 "Another huge thank you to the thirty volunteers today for your participation, without you we wouldn't be able to make it. Every help is precious."

1 September 2021/User 588 "I hear from many devastated people the feeling that they are abandoned! (from the beginning) Soon winter and the slowness of insurance and actions to help them are poor […] Wouldn't it be time to gather the voices of the disaster victims to put pressure on our policies to finally react to the height of this disaster?"

10 September 2021/User 603 "Update: solution found thanks to you! I'm leaving the post that might help other people! Cheer up to all […]"

In the subsequent three months, during the early reconstruction stage, Facebook platforms continued to be used to coordinate cleaning activities and offer help in October, while in November and December, Facebook users continuously expressed solidarity, urging courage and teamwork to facilitate repair and reconstruction efforts and achieve resilience.

5.3. Facebook sentiment analysis

Table 2 presents the outcomes of sentiment analysis, indicating the percentage distribution of each sentiment by month. There was a significant increase in optimism starting in August and remaining high through December, reflecting a growing positive outlook despite the crisis. Examples of posts expressing optimism include sentences of collective action, appreciation, and forward-looking statements, such as 'Already over 70 people on the site!!! Incredible how fast the group is growing.' Sadness and anger peaked in July, during the immediate aftermath of the crisis, at 41% and 38% respectively. As time progressed, these sentiments decrease but remain notable. Examples of posts that expressing sadness include: 'I sincerely hope that, although not 'Merry', Christmas will bring hope … ', 'Our beautiful stream and our beautiful forest … all destroyed!', and 'I can't stop thinking of all that was lost'. Joy was the least expressed sentiment across all months, peaking at 9% in November and decreasing to 2% in December. Posts expressing joy include the following: 'Thank you for your welcome, your energy, and your positivity!', In summary, while negative emotions such as Sadness and Anger were dominant in the

Table 2. Percentages of the occurrences of different sentiments expressed in Facebook posts per month.

	Sentiment			
Month	Anger	Sadness	Optimism	Joy
July	38	41	16	5
August	26	20	50	4
September	15	17	60	8
October	20	20	56	4
November	16	8	67	9
December	20	22	56	2

immediate aftermath of the crisis, optimism gradually grew stronger over time. The emotional landscape was complex, encompassing both ongoing challenges and emerging positive sentiments, highlighting the resilience and adaptability of the community.

5.4. Twitter users' profiles

Table 3 displays the countries and profiles of Twitter users. As can be seen half of the tweets were posted by individuals from Belgium. The second most frequent profiles were of media companies, followed by experts in different fields, including environmental engineering, geographical science, and climate change among others. Five percent of tweets are posted by politicians and decision makers such as mayors, members of the Belgian Walloon parliament, and members of the European parliament. There was a limited presence of aid and rescue services (2%), crisis management services (0.5%), and volunteers (0.4%) among the users' profiles; thus, while Facebook was predominantly used by members of the affected communities within Belgium, emphasizing localized, community-centric communication, Twitter served as a platform for broader global engagement and advocacy.

5.5. Tweets topic modeling

Given that the majority of the tweets covered the July period, the analysis of tweets gave only two consistent topics throughout the six-month period after the flood event (Table 4).

The most dominant subject in the first topic was climate, including climate change and the climate crisis:

Table 3. Countries and profiles of Twitter users.

Country	Percentage	Profile	Percentage
Belgium	55	Individual	51.5
France	14	Media	17
The Netherlands	7	Expert	6.5
USA	2.5	Politician/Decision-maker	5
UK	2	Aid rescue service	2
International	2	NGO	1.5
European	2	Activists	1.5
India	1	Weather warning	1
Germany	1	Crisis management	0.5
Other	13.5	Other	13.5

15 July 2021/User 47 A very strong thought to our Belgian friends and Liégeois this evening […] thousands of hectares of trees have been cut, the climate is racing all over the world. Let us become aware […] #flood #Belgium it is high time!

15 July 2021/User 58 Holidays cannot hide the ecological disaster at our door. Signals everywhere, yesterday the #Canada, today #Belgium and #Germany. In Africa, winter has never been so dry. The climate cause is also another relationship between people #floods.

15 July 2021/User 246 #ClimateChange #EU has to push more for changes before it is too late - I mean look at the floods in #Liège.

16 July 2021/User 379 rescue boats struggling in strong flows, hitting buildings as streets turn into rivers! unbelievable images coming in from Pepinster in Belgium. #climatechange is real and scary! #floods #Belgiumfloods #flooding #actionclimate.

Offering help, supporting victims, and showing solidarity were the dominant themes in the second topic:

24 July 2021/User 726 Still floods in #Belgium In #Dinant, the situation is deemed "catastrophic"! Solidarity with all Belgians #alltogether #Belgium #floods.

24 July 2021/User 741 #Solidarity #Belgium #flood What is still going on this evening in #Belgium is dramatic.

#floods Belgium / Platform for the exchange of services and goods.

25 July 2021/User 808 This solidarity tool aims to provide simple, fast, free and efficient help to victims of recent floods throughout Belgium […] #Verviers #Dinant #Namur.

Our results show that Facebook and Twitter played different roles in the immediate aftermath of the crisis. Facebook posts were detailed and logistical, focusing on immediate needs and specific actions; moreover, Facebook served as an effective platform for local, on-the-ground coordination and support among community members. Twitter served as a platform for broader, global engagement and advocacy, as tweets were more general, often linking the crisis to larger themes like climate change and attracting a diverse, international audience. This is in line with previous studies focusing on the extraction of flood-related topics during the 2021 Western Europe flood, including Belgium and Germany (Dujardin et al. 2024; Zander et al. 2023). Extreme weather events often trigger a surge in climate-related Twitter activity (Fownes, Chao, and Margolin 2018; Kirilenko and Stepchenkova 2014).

5.6. Tweets sentiment analysis

The sentiment analysis of tweets reveals that sadness was the most dominant sentiment, occurring in 65% of the tweets. Expressions of sadness included questions and statements

Table 4. Topic keywords extracted from tweets and their description details.

Topics	Keywords	Theme
Topic 1	Climate, weather, heavy, rain, nuisance, damage, climate crisis, climatechange, solidarity, victims, disaster, affected, death, terrible, courage	Flood event as an impact of climate change and solidarity with affected victims
Topic 2	Help, support, volunteers, solidarity, municipalities, commission, people, victims, social	Support and solidarity

such as the following: 'How to avoid new disasters in the future? At one point, we have no more solutions than to relocate', 'National mourning day', 'My family was able to take shelter, but the damage is terrifying', 'The bad news is that the terrible disaster in #Belgium/#Germany is caused by #climatechange', and 'Prayers for all impacted by the devastating floods. Greatly Saddened.' Anger followed at 10%, with expressions such as '#against looting #Belgium: We seem like a third world country', 'Above all, continue to stack the firefighters and the gendarmes who "are useless"', and 'Do not make this a circus to score political and ideological points', reflecting a notable presence of negative emotions. Meanwhile, optimism and joy occurred at 16% and 9%, respectively, indicating that positive emotions were less prevalent in the tweets. Expressions of optimism included the following: 'Despite concern, solidarity is extraordinary', and 'Incredible solidarity by brussels residents who responded to the call for donations'.

5.7. Interviews' thematic analysis

Table 5 presents the themes that emerged from the qualitative analysis under the five summarized question headings.

6. Conclusion

Our findings contribute to the ongoing discussion about the contribution of social media to community resilience. Given the lack of studies explicitly comparing Facebook and Twitter, our analysis examines the use of both platforms during the 2021 flood event in Belgium, shedding light on their respective impacts and functionalities.

During the flood event, characterized by widespread power outages and communication disruptions, mobile phone connectivity enabled individuals to stay connected on social media, which emerged as a crucial lifeline for information dissemination and community connectivity. Despite differing emphases, both platforms played pivotal roles in facilitating communication among affected individuals and mobilizing support networks. Twitter primarily served as a platform for immediate crisis updates, calls for solidarity, and linkage to broader climate change discussions. Conversely, Facebook groups were instrumental in the grassroots mobilization of community members, organizing volunteer efforts, and fostering community resilience in the immediate aftermath of the crisis and in the short term.

By integrating data from both platforms, this study does not claim direct equivalence between them but instead highlights their complementary roles in crisis response and community resilience. It is important to note that the corpora of text are fundamentally different. Twitter's concise, globally oriented posts and tweets are short and limited to a few characters and typically convey a key message to a general audience, often with no or few associated comments. Facebook's discussion-oriented posts in groups engage more localized, community-specific conversations. The differing structures and audiences of these platforms provide valuable insights into distinct aspects of public engagement and resilience, with Twitter addressing global awareness and Facebook facilitating local action. Twitter helps reaching a larger community of potential helpers, with calls for volunteering and donations reaching more distant places. Together, they offer a

Table 5. Thematic entries from qualitative analysis of interviews with Facebook administrators.

Interview questions	Emergent themes
Q1 Purpose of social media use during the flood crisis	**Theme 1: Information sharing** • Transmission of information about rising water levels and affected areas and needs of victims. • Announcement of limited communication through social media, with more reliance on phone calls for contact with people and institutions. **Theme 2: Community engagement and support** • Direct interaction with flood victims to understand and address their needs. • Management of volunteers who offered help through social media. • Encouragement of community support through publications and shared experiences. **Theme 3: Grassroots initiatives and community action** • Initiation of support groups for specific objectives, such as cleaning up the river and its surroundings and soliciting volunteers for on-site assistance.
Q2 Role of social media in joining efforts to address specific challenges during the crisis	**Theme 1: Mobilization and communication tool** • Facebook facilitated exchange between volunteers, victims, and public authorities. It was used to coordinate volunteer efforts by sharing information about the needs of the victims and organizing activities such as cleanup drives. • The limitations of social media in providing comprehensive support in some cases are due to its superficial and unstructured nature. **Theme 2: Spontaneous Mobilization** • Facebook was instrumental in mobilizing volunteers quickly and efficiently, facilitating the process of receiving donations, and encouraging community participation by sharing updates and success stories. **Theme 3: Overcoming Communication Crisis** • Social media usage, particularly on smartphones, helped overcome the communication crisis caused by infrastructure issues such as telephone and electricity cuts.

(*Continued*)

Table 5. Continued.

Interview questions	Emergent themes
	Theme 4: Disparities in Access to Information • Challenges were faced by certain segments of the population, such as elderly people or those with low incomes, who may have limited access to the internet or may not be active on social media platforms.
Q3 Role of social media in promoting community support during the crisis and post-crisis	**Theme 1: Increased Engagement and Solidarity During the Crisis** • Social media engagement was most significant during the crisis period. Platforms connected community members, enabling cooperation and relationship-building to address challenges. **Theme 2: Decrease in Engagement and Shift Towards Individual Concerns** • Despite the initial surge in support, engagement declined over time as people prioritized their personal situations. This shift led to a decrease in community engagement and support.
Q4 The impact of social media interactions on offline interaction	**Theme 1: Broader Reach and Scale** • Social media allowed for a wider dissemination of information and facilitated communication on a larger scale compared with offline interactions. It enabled individuals from diverse backgrounds and locations to participate in community efforts and offer support. **Theme 2: Legitimization of Efforts** • By showcasing the work being conducted and demonstrating the impact of community initiatives, Facebook helped legitimize the efforts of volunteers and organizations involved in the crisis response. This validation contributed to increased engagement and support from both online and offline communities. **Theme 3: Mixed Levels of Engagement** • While social media facilitated engagement and mobilized support, there were variations in the level of involvement among participants. Some individuals were actively engaged both online and offline, while others limited their participation to online interactions, such as liking, sharing, or offering virtual support.

Q5 Role played by social media in showcasing community resilience or unity during the flood crisis

Theme 1: Platform for Positive Narratives

- Social media provided a platform where positive stories of community support and resilience could be shared, contrasting with traditional media's focus on negative aspects. This helped to showcase the unity and solidarity within the community during the crisis.

Theme 2: Facilitator of Assistance

- Social media facilitated the exchange of information about available assistance, such as donations of furniture and electronics, and organized volunteer relief efforts, showing collective action and unity among community members.

Theme 3: Showcasing Community Efforts

- Social media served as a platform to showcase community efforts and achievements in overcoming challenges posed by the flood crisis. It highlighted the resilience and strength of the community in the face of adversity.

Theme 4: Delayed Awareness Among Victims

- Some victims of the flood crisis were initially disconnected from social media due to power outages and other challenges, causing delayed awareness of the crisis and online support networks. This may have affected their perception of the community resilience showcased on social media.

fuller picture of how social media can contribute to crisis management and community resilience.

While our analysis of posts revealed emerging topics and trends, interviews with Facebook administrators provided deeper insights into the nuanced dynamics of social media's contribution to community resilience. The lack of contextual information is often pointed out in existing studies as a major drawback of social media data analytics (Martí, Serrano-Estrada, and Nolasco-Cirugeda 2019; Yigitcanlar and Kankanamge 2022). The interviews contextualized the results obtained from the machine-learning LDA algorithm. Interviewees often provided temporal and contextual information based on their lived experience and interaction with Facebook members.

The integration of findings underscores the significant role of Facebook groups in enhancing volunteer effectiveness and fostering community support during the crisis. Furthermore, the support and connection experienced through Facebook groups during the flood event were significant and complementary to offline support from the local community. Additionally, while social media interactions facilitated broader engagement and motivated offline participation, offline activities were also shared on social media platforms, enhancing community involvement and support.

While Facebook administrators highlighted the synergistic relationship between online and offline community engagement, they also stressed the decline in social media engagement and offline support over time. Additionally, they noted that certain segments of the population, i.e. the elderly and the low socio-economic class, had limited access to the internet and were not very active on social media. The decline in support over time underscores the importance of sustained efforts to maintain community involvement beyond the immediate crisis period. Moreover, results from the interviews shed light on the need for targeted outreach initiatives and inclusive engagement strategies to bridge digital divides and ensure inclusion.

In conclusion, our study highlights the different roles played by Facebook and Twitter in natural disaster response. Facebook's strength lies in its ability to mobilize and organize local communities for immediate and practical support, while Twitter's strength is in its capacity to raise global awareness and connect local events to wider issues like climate change. Both platforms are crucial in enhancing community resilience, each serving distinct but interrelated purposes in post-disaster recovery efforts.

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Data availability statement

The data that support the findings of this study are openly available in Mendeley Data at https://data.mendeley.com, Reserved doi: 10.17632/78h67jgfrt.1.

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