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From Normal to Disaster Response Mode: How Can Virtual Communities Reconfigure Themselves to Respond Effectively to a Disaster?

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ABSTRACT

During a disaster, many people seek information from virtual communities. However, information overload, falsehoods and unrelated topics hinder information flow in virtual communities, putting disaster victims at risk. Given many disasters are generally of a short duration, we explore how virtual communities can quickly reconfigure themselves to respond effectively to a disaster. Drawing on risk society theory, our findings suggest reconfiguration is done via a series of cycles initially involving community members and subsequently featuring both community members and moderators working together to mitigate risks. We contribute to virtual community discourse on disaster response by showing how a virtual community can configure IT features to bring about change. Practically, we find transforming a virtual community from a normal to a disaster response mode requires (1) creating a controlled information hub, (2) promoting identity revelation and (3) allowing for temporary emergent hyperlocal leadership. While earlier IS research suggests that anonymity, openness and geographical dispersion are important for information dissemination in virtual communities, we suggest these practices may need to be changed during a disaster.

1 | Introduction

During disasters (e.g., hurricanes, earthquakes and pandemics), virtual communities can act as information providers to reduce victim uncertainty (Jurgens and Helsloot 2018; Qu, Wu, and Wang 2009; Houston et al. 2015). A virtual community is 'a group of people who communicate and interact, develop relationships, and collectively and individually seek to attain some goals in an IT-supported virtual space' (Ma and Agarwal 2007). For instance, people visit virtual communities to determine a disaster's magnitude, intensity and exact location and to keep themselves and their associates safe. Virtual communities can be important for disaster victims when they require quick assistance, and reliable, timely and useful information (e.g., the availability of shelters and resources).

However, most virtual communities are not designed to help with disaster management (Nan and Lu 2014; Qu, Wu, and Wang 2009; Reuter and Kaufhold 2018), instead being designed for other purposes (e.g., discussing pets and current events). When disaster strikes, virtual communities can amplify chaos, increase uncertainty and create more risks during disasters (Arif et al. 2016; Oh, Agrawal, and Rao 2013). For instance, many virtual communities support open participation (Lu and Yang 2011), which allows individuals to discuss diverse, non-urgent topics such as politics. While diverse

topics are valuable during normalcy to improve community engagement (Ren et al. 2012), this can foster risk by preventing disaster victims from urgently locating critical information (e.g., the condition of a particular street) during a disaster. Further many social media platforms for virtual communities encourage community members to participate anonymously (Prakasam and Huxtable-Thomas 2021). While anonymity can help protect one's privacy during normalcy, it also fuels risk by allowing individuals to spread falsehoods and detrimental information, which can worsen a disaster victim's situation (Luna and Pennock 2018).

Therefore, while virtual communities typically offer an inclusive space for socialising and discussing non-urgent matters during normalcy, we suggest their focus needs to shift dramatically during a disaster. Disaster victims need urgent and useful hyperlocal information related to safety, resources and recovery. However, some practices or policies (e.g., openness and anonymity) to manage a virtual community or disseminate information, designed for use during times of normalcy, may not be the most needed or useful during a disaster. Hence, to successfully manage a disaster, a virtual community as a whole might need to be reconfigured. This includes the way the IT works, the approach of authority figures (i.e., moderators) and the behaviour of community members (Jurgens and Helsloot 2018; Qu, Wu, and Wang 2009; Sakurai and Chughtai 2020).

Although the need for reconfiguration is suggested in prior virtual community discourse (e.g., Boh et al. 2023; Morton, Zorina, and Kudaravalli 2023), there is limited research into how it can be done to mitigate risks. Since virtual communities as a whole in normal times and during a disaster are different, it is critical to unpack the reconfiguration process to understand how virtual communities can effectively respond to disasters. Such reconfiguration must be done quickly as disasters are often short, intense affairs. Yet, how this reconfiguration can be done quickly remains an unanswered question. This study, therefore, seeks to address the following research question: *How can virtual communities reconfigure themselves to respond effectively to a disaster?*

To answer our research question, we conducted an in-depth interpretive case study of a virtual community, the r/Houston Reddit group, looking at how this community responded to the Hurricane Harvey hurricane disaster. We employ risk society theory (Beck 1992; Beck, Giddens, and Lash 1994) as a sensitising device to analyse the information disseminated by the r/Houston Reddit group during and immediately after the hurricane hit. Our findings contribute to virtual community discourse for disaster management by showing how reconfiguration involves a series of cycles involving (1) non-authority (i.e., community members) during the initial cycle and (2) the cooperation between non-authority and authority (i.e., moderators) in the subsequent ones. This cycle repeats until risks are fully mitigated. Practically, our findings suggest the key role of a virtual community in times of disaster is to manage the transformation and dissemination of authoritative information into trusted hyperlocal information. This requires (1) creating a controlled information hub, (2) promoting identity revelation and (3) allowing for temporary emergent hyperlocal leadership.

2 | Literature Review

2.1 | Virtual Communities During Disasters: Emergent Needs and Associated Risks

Virtual communities (e.g., Facebook groups, blogs, wiki and web discussion forums) are self-organising, voluntary, anonymous and open participation systems created and sustained through computer-supported communication (Ivaturi and Chua 2019; Lu and Yang 2011; Ray et al. 2014). During disasters, virtual communities are often created or appropriated to seek and provide disaster-related information. During Hurricane Katrina in 2005 (Procopio and Procopio 2007), the Sichuan earthquake in 2008 (Nan and Lu 2014), Cyclone Yasi in 2011 (Taylor et al. 2012), the Christchurch earthquake in 2011 (Bunker et al. 2013), the Thailand flood in 2011 (Leong et al. 2015) and Hurricane Maria in 2017 (Wyk and Starbird 2020), virtual communities were used by disaster victims to share and gather reliable information.

Virtual communities are necessary to address the emergent informational needs of disaster victims (Jurgens and Helsloot 2018). People need information from their fellow victims on the ground as well as from authoritative sources. While authoritative sources including the mainstream media provide some useful information, they often fail to provide information at a sufficiently granular level (Ludwig et al. 2017; Oh, Agrawal, and Rao 2013). Information dearth (i.e., lack of hyperlocal information needed by disaster victims) is a common problem observed in many disaster situations (Oh, Agrawal, and Rao 2013). For example, people need to know which road is safe to access, the locations of open shelters close to them, as well as evacuation instructions specific to their locale. As a result, during disasters, people often turn to virtual communities to reduce uncertainty about the situation. They praise each other's efforts, validate information, share expert opinions and provide emotional and social support to victims (Nan and Lu 2014; Qu, Wu, and Wang 2009; Tim et al. 2017; Vieweg et al. 2008).

However, using a virtual community for disaster information dissemination poses risks for disaster victims. First, information overload is a common risk during disasters (Hiltz and Plotnick 2013; Oh, Agrawal, and Rao 2013). Information may be disseminated by diverse sources (e.g., media outlets, emergency responders and humanitarian organisations.) and relayed by virtual community members. Such information can overlap and be contradictory (Rao, Plotnick, and Hiltz 2017). During disaster situations, community members need to obtain critical, trusted information (i.e., reliable, accurate and verifiable information) in a timely manner. This trusted information also needs to be hyperlocal (Grace et al. 2018; Hu, Farnham, and Monroy-Hernández 2013), such as information about rescue or emergency supplies that are available at a specific location, rather than of a more general nature.

Second, the trustworthiness of the information generated by virtual community members remains a critical concern. Previous research has demonstrated that virtual communities can be a source of misinformation (deliberate or unintentional) and rumours (Lu and Yang 2011; Luna and Pennock 2018; Oh, Agrawal, and Rao 2013; Roy et al. 2020; Silver and Matthews 2017). This

can create difficulties for disaster victims who often cannot differentiate between trustworthy and false information. Many incidents have arisen where malicious community members have disseminated misinformation in virtual communities during times of disaster (Luna and Pennock 2018). For example, during the 2011 Japan earthquake and tsunami, wrong shelter locations were disseminated deliberately. False reports of explosions were propagated during the Mumbai terrorist attack in 2008. Because of the urgency of disaster situations, community members often do not have time to authenticate information before sharing it with others (Rajdev and Lee 2015). This risk is further heightened when individuals remain anonymous. Although anonymity protects one's privacy and allows individuals to express themselves more freely without fear of judgement (Kaufhold et al. 2019; Yates and Paquette 2011; Zheng, Zhao, and Stylianou 2013), it can encourage individuals with malicious intent to spread misinformation without concern of repercussion.

Third, information relevance (i.e., level of usefulness) is another known concern in disaster times (Ludwig, Kotthaus, and Pipek 2015; Pearson, Tadisina, and Griffin 2012). Community members discussing non-urgent, unrelated topics such as gardening can make it challenging for community members to urgently sift through and find useful information. This risk is exacerbated due to the open participation nature of virtual communities. Although during non-disaster periods open participation allows community members to discuss various topics, share different opinions and engage in long-term discussions across multiple threads (Hamilton, Garretson, and Kerne 2014) it can backfire in disaster times and lead to irrelevant and ill-timed discussions. Also, both the ignorant and informed can provide input. Disaster victims following advice from those who lack necessary expertise can put their lives at risk. For example, during the COVID-19 outbreak, multiple individuals consumed bleach to ward off the virus based on uninformed advice (Litman et al. 2023).

Based on the above discussion, we can say that virtual communities are crucial in disaster response to address emergent informational needs. However, there are inherent risks that must be navigated for virtual communities to effectively respond to new demands posed by the uncertain nature of disasters. Table 1 illustrates the risks virtual communities face during a disaster.

We suggest that virtual communities in normal times and during times of disaster differ and can serve distinct purposes (see Table 2). Virtual communities in normal times mainly

TABLE 1 | The risks virtual communities face in disasters.

Risk(s)	Description and consequences	Example(s)
Information overload	Community members are overwhelmed by the vast amount of information (including accurate and false), leading to difficulties in finding trusted information.	Large volume of articles shared in the virtual community comprising both true and unsubstantiated information.
Information trustworthiness	Lack of reliable, accurate and verifiable information leads community members to make misinformed decisions.	Misinformation related to weather and shelter locations.
Information relevance	Lack of useful and applicable information to the disaster context or need, encouraging community members to take risky and life-threatening behaviours.	Non-urgent discussions such as politics and lifestyle-related topics.

TABLE 2 | Differences between virtual communities in normal times and disaster times.

Characteristics	Virtual communities in normal times	Virtual communities during times of disaster
Purpose	Communicating shared interest, hobby or activity	Responding to a disaster
Primary focus	Socialising and community engagement	Providing critical hyperlocal information, real-time updates including safety measures, evacuation procedures and other emergency services
Information preference	Diverse	Hyperlocal
Information acceptance	Everyone has their opinion and is valued equally	Expert opinion is valued over uninformed lay opinion
Information timeliness	Low, non-urgent	High, time-sensitive

focus on socialising and community engagement. They prioritise creating an inclusive environment where everyone has their opinion. Information timeliness may not be critical because community members often engage in long-term discussions on diverse topics. In contrast, virtual communities during a disaster prioritise critical hyperlocal information and real-time updates. Timely information becomes critical, such as weather updates and shelter locations. Community members focus on immediate survival rather than socialising. They offer emotional support, resources and coordination for those affected by disasters. Community members also value expert opinion over uninformed lay opinion to make informed decisions.

Individuals react in unforeseeable ways in disaster times (Majchrzak, Jarvenpaa, and Hollingshead 2007; Tim et al. 2017). Some existing practices or policies (e.g., openness and anonymity) to manage a virtual community or disseminate information may not be the most needed, useful or appropriate during disasters. This is because the emergent needs and risks resulting from the disaster demand new ways of doing things (Boh et al. 2023; Majchrzak, Jarvenpaa, and Hollingshead 2007; Pan, Pan, and Leidner 2012).

The social media platforms of virtual communities (e.g., Twitter, Reddit and Facebook) provide IT features that virtual community members (moderators) can use. These features include ways of sorting and ranking threads, ways of making threads permanent (e.g., sticky), application programming interfaces (APIs) to automate tasks, for example, to help detect aberrant community behaviour, and ways to exclude community members from a virtual community. Of the smorgasbord of IT features available, moderators choose which features to configure so the virtual community adapts to the situation. It enables them to control community members' privileges, cultivate norms, organising activities, lead discussions and moderate content (Ivaturi and Chua 2019; Kilgo et al. 2016).

Because virtual communities as a whole in normal times and during a disaster are different, the virtual community has the option to add, remove and change mechanisms, that is, be reconfigured to respond to a disaster. Such reconfiguration must be done quickly as disasters are often short, intense affairs. However, even though prior virtual community literature suggests the importance of reconfiguration during disasters (Boh et al. 2023; Morton, Zorina, and Kudaravalli 2023), there exists limited empirical evidence into its process. Unpacking how reconfiguration can be pursued is crucial to understanding how virtual communities can adequately cope during disasters. The potential pitfalls for virtual communities not opting for reconfiguration include the following risks for disaster victims: high levels of misinformation, information overload, low information relevance and the experience of uncivil behaviours (e.g., trolling) (Hiltz and Plotnick 2013; Oh, Agrawal, and Rao 2013; Ludwig, Kotthaus, and Pipek 2015; Pearson, Tadisina, and Griffin 2012; Luna and Pennock 2018). Together these risks may encourage disaster victims to engage in risky behaviours. These include going to wrong shelter locations or re-entering an evacuated area prematurely based on hearsay. We argue that these risks can be mitigated if virtual communities can effectively reconfigure themselves from a normal to disaster response model. Yet, how this reconfiguration can be done quickly remains an unanswered question. The motivation of this paper is therefore to address the following question: *How can virtual communities reconfigure themselves to respond effectively to a disaster?*

To date, IS studies on disaster response have explored the role of social capital (Lu and Yang 2011), boundary objects (Tim et al. 2017), self-organisation (Nan and Lu 2014), collective sense-making (Stieglitz, Mirbabaie, and Milde 2018) and empowerment (Leong et al. 2015) in information exchange. These studies have highlighted the importance of virtual communities during disasters and primarily focused on the positive implications. However, existing IS research does not explain how virtual communities can simultaneously fulfil emergent needs while suppressing emergent risks during a disaster. There has been a call for further research to investigate how virtual communities can manage the negative unintended consequences (e.g., problematic rumours and information overload) of social media use during disasters (Tim et al. 2017). Further research to uncover what configurations of IT features are effective in virtual communities during disasters has also been advocated for (Morton, Zorina, and Kudaravalli 2023). This paper is one answer to these calls.

This paper draws on risk society theory (Beck 1992; Beck, Giddens, and Lash 1994) which argues risk has become a principal defining feature of modern society (Beck 1994; Giritli Nygren and Olofsson 2020; Olofsson and Öhman 2007; Straub 2020). We choose risk society as our guiding theory because it specifically examines risks arising from the existing systems of modern society and how such risks are addressed. Our specific problem looks at risks arising from the use of virtual communities (an existing system in modern society) in times of disaster. Other theories (e.g., structuration and socio-technical systems) focus on specific aspects of systems or interactions and do not adequately address how risks provoke decentralised responses. By contrast, risk society theory captures how risks are distributed, perceived and managed in interconnected systems.

2.2 | Risk Society Theory

Risks are possible detrimental outcomes resulting from an event or human activity subject to hazard(s) (Hardy et al. 2020; Renn and Benighaus 2013). Given risk is omnipresent, societies create systems to manage risk. A *system* is a combination of interrelated components, including mechanisms, rules, roles and processes (Gharajedaghi and Ackoff 1984; Jalava 2003; Valacich and Schneider 2010; Zinn 2008). These components work together to shape the way society operates. *Mechanisms* are the specific tools (practical means) and integral components of a system used to achieve outcomes (Nurmi 2010). The system sets the rules, roles and processes that govern how society functions (e.g., how to use mechanisms, enforce policies and assign roles). To illustrate, traffic lights serve as a mechanism in transportation systems. Traffic lights are guided by rules that dictate when to stop, proceed with caution or accelerate.

Key to risk society theory is that in our current society, risk is no longer caused only by external conditions (e.g., natural disasters) but also by modernity (i.e., a movement away from

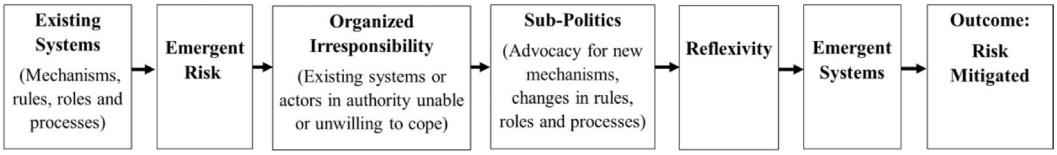

FIGURE 1 | The risk mitigation process of risk society theory.

traditional forms of life or ideas) itself (Beck 1992; Beck, Giddens, and Lash 1994; Giddens 1999; van Bueren, Lammerts van Bueren, and van der Zijpp 2014). For example, global warming is associated with human activity (carbon emissions due to industrialisation); nuclear power plant meltdown risks are wholly associated with human devices (viz. nuclear power plants). That the most dangerous risks to society arise from society itself creates the '*risk society*', a world where risks are human-generated, complex and potentially threaten the existence of humanity on a large scale (Giddens 1999; Giritli Nygren and Olofsson 2020; Matten 2004).

We suggest virtual communities are part of the risk society, because the same virtual communities used to help obtain useful information can generate more risk and threaten human lives. During disasters, virtual communities can spread falsehoods (e.g., misinformation and rumour) and promote socially unacceptable behaviours such as bullying (Luna and Pennock 2018; Oh, Agrawal, and Rao 2013).

In risk society theory, risk is a driving force for social change (e.g., a major source of solidarity) where social actors (e.g., individuals or organisation) deal with hazards and insecurities stemming from modernity (Beck 1992; Giritli Nygren and Olofsson 2020; Olofsson and Öhman 2007). Flaws in *existing systems* render society incapable of mitigating *emergent risks* (i.e., risks that arise as a result of society changing) (Chan 2008; Dwyer et al. 2021). One key flaw of existing societies is *organised irresponsibility* (Ekberg 2007; Matten 2004; Mythen 2018), which arises from the relationship between social actors (i.e., individuals and organisations). In organised irresponsibility, the social practices or actions of many social actors collectively generate risk for others, and because responsibility is diffused, no one takes responsibility (Beck 1998; Curran 2018; van Bueren, Lammerts van Bueren, and van der Zijpp 2014).

As a result of organised irresponsibility, the systems society creates to control and manage emergent risks fail. They flag emergent risks as incompatible with themselves and chase other objectives single-mindedly instead. When incidents (e.g., accidents) arise from emergent risks, humans in the risk society blame existing systems for not acting appropriately (Béland 2007). These humans alienate themselves from existing systems and develop new systems (Beck 2009; Hoogenboom and Ossewaarde 2005; Wynne 1996). Alternative forms of political interaction emerge, which risk society theory calls '*sub-politics*' (e.g., activist groups) (Beck 1992; Beck, Giddens, and Lash 1994; Chan 2008). Sub-politics emerges when traditional systems struggle to maintain their legitimacy, and new non-traditional social actors enter the debate (Beck 1998; Guivant 2016). Non-traditional social actors increasingly pressure and question the status quo. As a result, significant societal change (i.e., reorganisation of power and responsibility) and transformation occur to cope with emergent risks (Chan 2008).

The new systems arising from sub-politics also struggle to gain legitimacy while facing demands for solutions to solve emergent risks (Beck 1994; Chan 2008; Edmeston 2010). Their actions only gain legitimacy when humans become aware of the sub-politics and get involved in mitigating emergent risks. How legitimacy is obtained is highly situated. How others view and act towards the new systems arising from sub-politics in the risk society is called '*reflexivity*' (Guivant 2016; Olofsson and Öhman 2007). Reflexivity is the capacity of social actors to show awareness and some kind of active strategy to handle risks (Giddens 1990; Lash 1994; Olofsson and Öhman 2007). Reflexivity is thus an individualised response to the uncertainty and contingency that defines the risk society (Ekberg 2007). Some people in the risk society confer legitimacy on the *emergent systems* while others resist it. Given enough people, the new system gains sufficient legitimacy such that the *risk is mitigated*. The risk mitigation process of risk society theory is summarised in Figure 1.

2.3 | The Role of Social Media Platforms and Interdependency of Social Actors in Risk Society Theory

Risk society theory thus explores (1) the inability of existing systems to cope with emergent risks and (2) the innovation required to mitigate emergent risks. Although risk society theory offers a sound perspective to examine risk mitigation, it has two limitations that may not seamlessly apply to understanding risk mitigation process in virtual communities.

First, risk society theory lacks an explanation of how it relates to specific situations. In our case, the role of a virtual community using IT features to increase or decrease risk during a disaster. Virtual communities depend on social media platforms for their existence. The IT features available on social media platforms can create or mitigate risks (Lupton 2016). For example, social bots (an IT feature) were used to deliberately spread misinformation in the 2016 US election (Bessi and Ferrara 2016). By contrast, social bots were used during the 2011 Japan earthquake to automate earthquake warnings on Twitter (Haustein et al. 2016). Therefore, we believe virtual communities need to understand how they can use IT features to create, distribute or mitigate risks.

We define and describe social media platforms as follows. A *social media platform* refers to computer-based tools (such as websites and apps) for individuals to create and share content with others and/or participate in a community (McKenna, Myers, and Newman 2017). The social media platform provides each virtual community with a set of *IT features*, which

are the designated functionalities built into it (Majchrzak and Markus 2012). An IT feature has action potentials that are not realised in practice until a user *actualises* them to achieve an outcome (Vaast et al. 2017). For example, Reddit is a social media platform that allows community members to form topical communities, within which community members can create, comment and vote for threads (Hamilton et al. 2018). One of the IT features of Reddit is voting (i.e., upvote and downvote). While the voting feature always has the potential to influence content visibility, this potential is only realised when users engage with this feature to achieve the desired outcome of promoting or demoting content.

Virtual community members (e.g., moderators) choose among various IT features which ones they are going to use to shape virtual community member behaviours. The choosing, assemblage and adaptation of these IT features creates a configuration embodied in a specific *mechanism* (Suchman 2012). For example, the thread (mechanism) works in a specific way in a particular virtual community (the configuration). The thread is based on multiple IT features, including the sorting, ranking, and liking of information. The sorting of threads in turn shapes behaviours. Because threads are sorted in a certain way, virtual community members are more likely to read certain threads over others.

However, the mechanisms alone are insufficient to shape desired behaviour. *Governance systems* have to be introduced on top of the mechanisms, including introducing rules for how the mechanisms are to be used (Jalava 2003; Valacich and Schneider 2010; Zinn 2008). Figure 2 illustrates the technology-driven relationship between a social media platform, IT features, mechanisms, governance system and virtual community member behaviour.

Second, risk society theory pays limited attention to the interdependency of social actors. It does not specify the roles of different institutional and individual actors and their interrelationships in the production and mitigation of risk, particularly, the relationship between authority and non-authority (i.e., sub-politics). Risk society theory primarily considers sub-politics as alienated from existing systems (Beck 2009; Wynne 1996). However, actors central in society can engage in sub-politics. For example, government authorities cooperated with non-government organisations (NGOs) to reshape environmental policies in Australia (Lane and Morrison 2006). Therefore, while risk society theory highlights the need for sub-politics in mitigating risks, it falls short in detailing how these sub-political actors (i.e., community members) in virtual communities gain recognition and are able influence the actors in authority to enable change. This is important because moderators in a virtual community hold significant power in shaping discourse, creating or enabling mechanisms and enforcing norms or rules (Ivaturi and Chua 2019).

Our application of the risk mitigation process of risk society theory (Figure 1) (Beck 1992; Beck, Giddens, and Lash 1994) and the technology-driven relationship of social media platform (Figure 2) (e.g., McKenna, Myers, and Newman 2017; Majchrzak and Markus 2012) serves as the sensitising device for our analysis discussed in the following sections.

3 | Methodology

We conducted an in-depth interpretive case study of a virtual community, the r/Houston Reddit group, looking at how this community mitigated the risks associated with Hurricane Harvey in 2017 (Klein and Myers 1999; Walsham 1995). Walsham (2006) says that generalisations from interpretive case studies 'can take the form of concepts, theories, specific implications or rich insights' (Walsham 2006, 322), even though the data might be obtained from just one or a few organisations. In our case, we studied just one virtual community (r/Houston) and how it responded to a disaster (Hurricane Harvey). The process of data collection and analysis was iterative, as explained more fully below. We believe that the concepts and insights we obtained show how virtual communities can reconfigure themselves to respond effectively to a disaster. Figure 3 shows a map and the timeline of Hurricane Harvey's progress.

On August 25, 2017, Hurricane Harvey made landfall near Corpus Christi, Texas with 130 mph winds. Later, Harvey moved slowly inland towards Houston where it remained for 4 days and caused extreme widespread flooding. Substantial virtual community activity arose during the hurricane. Unfortunately, the official emergency number, 911, was overloaded and victims turned to virtual communities to request help (Luna and Pennock 2018).

3.1 | Case Selection

We chose r/Houston on Reddit as our case site for three reasons. First, this community focuses on local issues, people and events pertinent to the Houston area and allows diverse topics. Hence, the case site provided an opportunity to explore how this community changed its design to fulfil the emergent needs (e.g., receiving hyperlocal information and expert opinions) of disaster victims during a disaster.

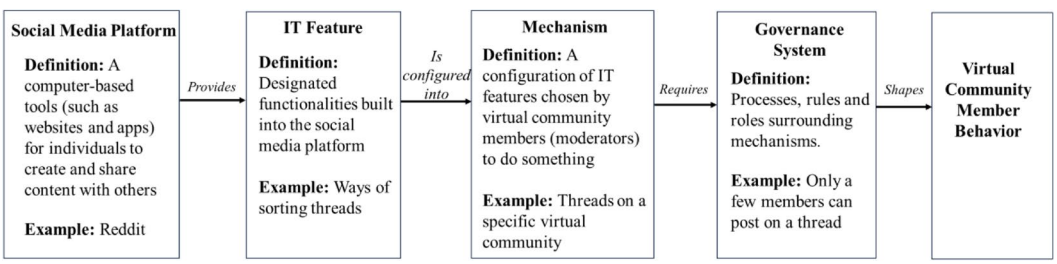

FIGURE 2 | Social media platform, IT feature, configuration and governance system.

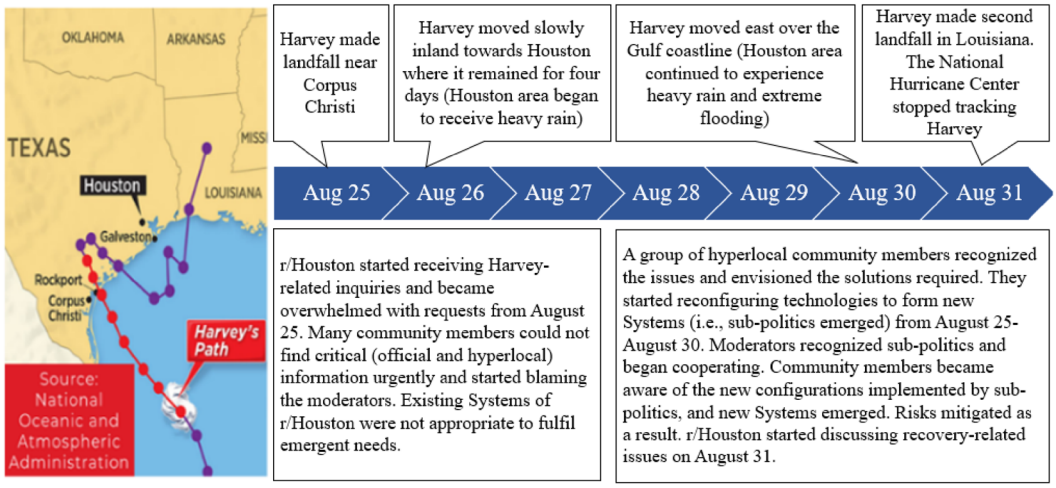

FIGURE 3 | Hurricane Harvey timeline.

TABLE 3 | Summary of r/Houston activity level.

Case site (r/Houston Subreddit)	Before (August 11–August 24, 2017)	During (August 25–August 31, 2017)
Total number of threads created	1024	5315
Total number of comments made	19986	99078
Average # of threads created per day	73	759
Average # of comments posted per day	1427	14154

Second, we know substantial virtual community activity arose during the hurricane. The r/Houston community was not designed for disaster response, but community members were highly active during Hurricane Harvey. Table 3 summarises the activity level of the community both before and during the disaster. Critical to our research context, this community allows open and anonymous participation (i.e., anyone can participate). Therefore, information overload, overlap, falsehoods and socially undesirable behaviours were present during the hurricane, again aligning with our research question. For example, we discovered rumours of a shark swimming on the freeway and of the city of Houston checking immigration documents at shelters, deterring immigrants from seeking help.

Third, this community was active for at least 5 years before Hurricane Harvey hit Houston. There were existing systems in place, including an established leadership structure. It was thus possible to explore how existing systems associated with this virtual community changed to fulfil emergent needs and mitigate emergent risks.

3.2 | Data Sources

We used community-generated archival data in Reddit as the principal data source. Reddit is a social news aggregation, web content rating and discussion platform of self-governed virtual communities.

Reddit was an ideal platform to study for four reasons. First, most other research studies have focused on social media platforms such as Twitter (Kapoor et al. 2018; Oh, Agrawal, and Rao 2013; Starbird and Palen 2011; Wyk and Starbird 2020), where communities and topics are intermingled across the platform. It is thus difficult to ensure one has obtained all relevant content pertaining to a particular event (e.g., a natural disaster). By contrast, Reddit naturally divides itself into 'subreddits' (i.e., defined subcommunities that focus on specific interests) (Buyukozturk, Gaulden, and Dowd-Arrow 2018), which allowed us to focus on the specific community of members engaged in surviving Hurricane Harvey. Second, Reddit provides much richer content than other platforms that apply restrictions on content length such as Twitter (Stoffel, Jaeckle, and Keim 2014). Third, Reddit data are open and archived. Therefore, it is relatively easy to trace the evolution of a conversation to identify where risky behaviours (e.g., spreading falsehoods and irrelevant content) began on the virtual community, and how others responded. Fourth, it is possible for others to validate our data sources because they are publicly available (Miles and Huberman 1994). In addition, we obtained a range of archival data from online newspaper, magazine reports available in Emergency management organisations' (EMO) website and social media posts of EMOs (e.g., Federal Emergency Management Agency, Houston Police, Houston city council; Houston mayor). We collected data from these sources to capture contextual information (Benbasat, Goldstein, and Mead 1987, 374) related to the disaster event. For example, these data enabled us to determine the timeline of the disaster and extract information regarding affected areas, as well

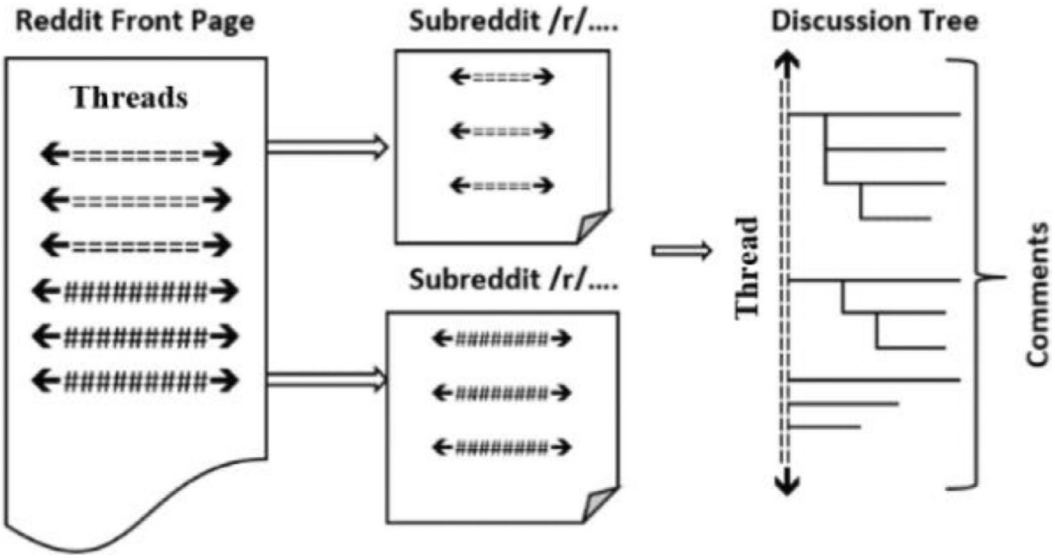

FIGURE 4 | Schematic structure of virtual communities (subreddits) on Reddit.

as cross-check claims made on the r/Houston community against authoritative sources.

Figure 4 presents the schematic structure of the virtual communities (subreddit) and illustrates a thread (discussion tree) in r/Houston, composed of nested comments. The threaded discussion starts with an initial post (i.e., the first comment by original poster) followed by further comments replying to it. The discussion follows a tree structure where community members may reply to the initial post or comments. Furthermore, the Reddit platform allows registered community members to express their positive and negative opinions about threads and comments by using an upvote (an IT feature similar to 'likes' in Facebook) or downvote, respectively.

3.3 | Data Collection

We collected digital trace data (i.e., digitally recorded and time-stamped logs of activities and events) on Reddit. Digital trace data provide relatively precise and voluminous data on actions and events and hence is useful for theorising about processual phenomena (Pentland et al. 2020). We first collected all threads that were created around the time of Hurricane Harvey from the selected case site (see Table 3 for details). These were principally extracted using the Reddit search tool. However, the Reddit search tool restricts the amount of data one can retrieve in one query to 1000 threads. Therefore, we also used the publicly available data from Reddit archived on Google Big Query. We collected threads in the 2 weeks before the hurricane (August 11–August 24, 2017) and during the hurricane (August 25–August 31, 2017). We checked (by extracting and reading the threads) and found that no threads about the hurricane occurred 2 weeks prior to August 25.

Data from the 2 weeks before the hurricane (August 11–August 24, 2017) provided a baseline observation of the case site to understand existing systems and community behaviours. This study focuses on how virtual communities can quickly transform from a normal mode to a disaster response mode. Thus, the focus was the 5315 threads containing 99 078 comments associated with Hurricane Harvey created during the hurricane (August 25–August 31, 2017).

3.4 | Data Analysis

We began by analysing the data iteratively, alternating between open coding and investigation of theories that might fit the emerging interpretation. This initial analysis involved two stages. In the first stage, we analysed data at the thread level. Following the suggestions of McKenna, Myers, and Newman (2017), we used the qualitative data analysis tool Leximancer (i.e., a specialist content analysis software) to conduct an unstructured analysis of the case data. Leximancer enables automated extraction of concepts and themes based on frequency counts and relational co-occurrences of words in text in a two-sentence block. It then produces a conceptual map illustrating the relationships between different themes and concepts (Indulska, Hovorka, and Recker 2012; Malik, Froese, and Sharma 2020). Once initial concepts were identified, we discarded irrelevant words (e.g., &amp, &gt, https and http) to minimise the noise in the data. Following Malik, Froese, and Sharma (2020) we employed the editing function to merge plural words, for example, 'area' and 'areas' into 'areas' and so on, grouping similar concepts together. The above process created a set of Leximancer themes (i.e., clusters of frequently co-occurring concepts).

However, Leximancer does not name themes based on context. Rather, the software assigns the most prominent concept within the cluster as the theme name. For this reason, it has been suggested that human interpretation is required to make sense of Leximancer's output (Schmidt et al. 2019). Researchers need to extensively review the nature of the dialogue within each theme (i.e., inspections of each concept within a theme and extract supporting quotes to justify the interpretation) and rename a theme or group them if necessary to accurately reflect its nuance and context (Indulska, Hovorka, and Recker 2012; Schmidt et al. 2019). Therefore, we first interpreted, renamed

TABLE 4 | Summary of interpretive codes.

Codes	Description
Initial response	
Emergent risk	Observed by the activity of a community member or any event that led to negative consequences.
Existing mechanisms and governance system	The current configuration of IT features to cope with emergent risk and the rules surrounding the use of these IT features.
Organised irresponsibility	The inability of existing mechanisms and governance system or unwillingness of actors in authority to cope with emergent risk.
Sub-politics	
Negative reaction with existing mechanisms	A negative emotion expressed by community members regarding existing mechanisms.
Proposed new solution	Action by community members to propose new solutions to cope with emergent risk.
Implement the proposed solution	Action by community members and moderators to implement the proposed solution to cope with emergent risk.
Reflexivity	
Reaction towards the implemented solution (i.e., emergence of new mechanism)	Community members' desire to use or resist the proposed solution.
Outcome of the new solution	Indications that emergent risk is mitigated.
IT features	
Designated functionalities built into the social media platform.	Repeated examples of community members doing things with Reddit IT features. Repeated examples of a change in what community members did with Reddit IT features.
Mechanisms	
Configuration of IT features	The aggregated uses/changes of uses of users encapsulated in a single (to the user) recognised object.
Governance system	
Processes, rules and roles surrounding identified mechanisms	Examples of rules enforced in mechanisms. Examples of community members and moderators taking different roles to perform specific tasks.
Recognition by authority	
Moderator's understanding of the usefulness of a mechanism	Examples of moderators acknowledging new mechanisms based on two factors: (i) the material presence of a mechanism (e.g., megathread) and (ii) the reputation or success of the mechanism.

and grouped the themes by reading the threads and comments in each theme.

The five initial themes we identified based on the Leximancer output were titled *Houston, Need, People, Anyone* and *Safe*. After reviewing the threads and associated comments captured in these themes, we sensed that underlying these Leximancer themes were the themes *Need for local information* (i.e., threads related to seeking and providing situational information, advice and suggestion), *Shared emotional connection* (i.e., threads expressing gratitude, showing sympathy and benevolence) and *Negative reactions* (i.e., threads expressing fear, anxiety and anger or frustration).

Although the above process helped us make some sense of the data, it was not adequate to answer our research question. However, while interpreting the threads and comments in each theme identified by Leximancer, we noticed particular patterns. Specifically, a consistent storyline in the threads had community members who lived in Houston having difficulty finding information from traditional sources such as government websites. These community members then turned to the r/Houston community to seek local information pertinent to their respective area. However, while r/Houston had a lot of relevant information, these community members faced problems finding this. We recognised that the existing mechanisms (i.e., configurations of IT features) and governance system (i.e.,

rules, roles and processes) that the r/Houston community used made it difficult to find relevant information easily. This led to community members becoming frustrated with the subreddit and blaming the moderation team for problems. However, moderators followed existing routines to disseminate disaster information and denied any changes (organised irresponsibility). We also discovered that the failure of existing mechanisms or the unwillingness of moderators created situations where some community members proposed new solutions to manage disaster information more effectively (sub-politics). Subsequently, other community members became aware of the proposed new solutions and started using them (reflexivity). They found the new solutions were useful and appreciated those involved in sub-politics (outcome).

We therefore applied risk society theory as a lens (Beck 1992; Beck, Giddens, and Lash 1994) and found it provided rich insights. However, and importantly, we remained open to any new themes emerging in the data. We met regularly to review codes and the consistency of the coding (Klein and Myers 1999). In our coding, we observed that the use of IT features of the social media platform (i.e., Reddit) enabled and constrained the dissemination of disaster information. For example, during the disaster, moderators used 'highlighting' IT feature to make important information prominent. As risk society theory does not emphasise the role of social media platforms and its associated IT features, we added codes to describe the specific enabling and constraining features of the platform. Furthermore, we recognised the impact of networked interactions on risk production/mitigation. Particularly, we observed how sub-politics influenced moderators and how moderators engaged in sub-politics to minimise disaster-associated risks. For example, moderators created new flairs to indicate particular community members' location and professional expertise. We summarise the final codes applied in Table 4 below. The risk society codes were applied to the threads in the following way:

- Emergent risk: We first attempted to identify *emergent risk*, defined as any activity of community members or event that led to negative consequences. For example, a community member asked for emergency numbers and expressed frustration at not finding them easily. The community member then complained about the subreddit not being useful.
- Organised irresponsibility: We further wanted to find out why the existing systems or actors in authority (i.e., moderators) were unable or unwilling to cope with the emergent risk. For example, moderators accepted limitations of hyperlinks and allowed community members to arbitrarily create new threads.
- Sub-politics: We then followed the thread to explore further evidence of dissatisfaction (by the original poster or others) and/or their desire to cope with emergent risk by proposing new solutions. For example, other community members echoed the original person's frustration at not finding the emergency numbers. Soon afterwards, someone suggested compiling all emergency numbers into a single thread.
- Reflexivity: We attempted to identify how community members acted towards the sub-politics (*reflexivity*). We checked whether the community members supported or resisted the new solutions. For example, community members started following the thread that was compiled earlier to find emergency numbers. Furthermore, we observed outcomes of the new solutions proposed by the sub-politics (i.e., new mechanisms emerged and succeeded or failed to mitigate emergent risks). For example, expressions of gratitude suggested that the new solutions were now stabilised and used by community members.
- IT features and mechanisms: Within the existing systems and sub-politics, we paid special attention to how the IT features were being used. Each concrete example of a use and for sub-politics a change of use was identified. For example, if we found multiple instances of community members asking how to sort something, and the sorting technique was changed, sorting was identified as an IT feature that was reconfigured. We then traced the assemblage of these changed IT features to identify the mechanisms. For example, the change in sorting was emplaced within the megathread, which included the sorting, sticky and flair IT features.
- Governance system: Once the mechanisms were identified, we looked at the rules imposed over what acceptable use of the mechanisms were and how those rules were enforced. To do this, we looked for sanctioning, that is, community members being informed a particular action involving the mechanism was inappropriate. How the sanction was conducted allowed us to identify acceptable use of the mechanism and rules and processes for enforcement. For example, attaching evidence was mandatory when posting any claims in the megathread. We also looked for examples where community members were assigned to or volunteered for roles. For example, a group of community members were recruited to maintain the livethread. Moderators had a role to curate/highlight information, ban problematic community members, etc.
- Recognition by authority: We analysed how moderators understood the usefulness of mechanisms suggested by sub-politics (community members). Particularly, we examined how they witnessed the material presence and reputation of those mechanisms.

After our theoretical coding, we compared the process flows (as captured by the codes) across the threads. We observed common patterns across the sub-politics (i.e., how new mechanisms and governance system emerged). Specifically, we observed the following patterns: *recognising changing community needs and priorities, envisioning and reconfiguring IT features*, *envisioning governance system, deferring to temporary emergent hyperlocal leadership*, and *discriminating towards hyperlocal community members*. We then compared these patterns with the established literature. To our surprise, these patterns seemed to contradict the recommendations found in previous IS and disaster management literature. We then returned to our data to verify whether there was evidence contradicting these discovered patterns. Finding none, these common patterns became the central theme of this paper. The four vignettes discussed below illustrate how risk was associated with information dissemination and how new systems (mechanisms and governance system) emerged to cope with these risks.

4 | Findings

4.1 | Vignette 1: The Need for Collated Authoritative Information

Emergent risk: During Hurricane Harvey, multiple authoritative sources (e.g., the National Weather Service Houston/Galveston station, the Houston Police, National Hurricane Centre, News broadcasting channels, Mayor of Houston) issued important information such as weather updates, warnings, advice on how to use water and so forth. However, there was no centralised information hub that compiled all the authoritative information into a single place. Community members busy coping with the disaster often were unable to collate this information for their own use.

Initially r/Houston community members sought authoritative information from traditional collation services. However, they found that these services were not valuable, because they targeted a multitude of audiences, not just the disaster-stricken community. The quote below is from a member who tried looking for information on a virtual news community:

> The /r/news Livethread was hot garbage. What Houstonians need are other locals who actually know what's going on. Not non-locals (who don't know shit about what's going on) tossing blame at this official and that official.

Hence, they turned to the r/Houston subreddit to find authoritative information pertinent to the Houston area.

IT features and mechanisms: Initially community members arbitrarily created threads using several content publishing features (i.e., text, image and video). Although a few community members circulated authoritative information, this was scattered across multiple threads which made it difficult to locate specific information quickly. For instance, one member was looking for information about road closures, openings and water levels.

> My 62 year old mom needs me to come to Houston and take her to a hospital for hip pain ASAP. How will I know when it's safe to drive there? Where do I get official information about road closures/openings and water levels?

Another IT feature of the Reddit platform is that community members can insert hyperlinks (e.g., tweets by the national hurricane centre) into a comment to direct other community members to important information. However, this way of obtaining information is time consuming because the community member must manually click each hyperlink which then redirects to the original source. If one is trying to obtain information from multiple sources (e.g., information about road closures and water levels), this can be time consuming.

Governance system: No governance system was in place to give prominence to information from authoritative sources. In some cases, existing governance systems impeded the provision of such information. When community members commented with only a hyperlink (even if authoritative) without adding other texts, the AutoModerator flagged such comments as spam and automatically deleted them.

> This submission has been automatically removed for being posted in a manner consistent with spam in the subreddit.... I am a bot, and this action was performed automatically.

AutoModerator is a feature offered by the Reddit platform that automates moderation tasks. AutoModerator has no global behaviour and operates based on predefined rules set by subreddit moderators to remove or approve content based on specific criteria.

Organised irresponsibility: The existing moderators demonstrated organised irresponsibility by accepting the limitations of hyperlinks without seeking an alternative solution. They continued using the AutoModerator with predefined rules that could not distinguish between authoritative and unreliable sources. Besides, moderators allowed community members to continue creating arbitrary individual threads.

Sub-politics. ***Desire by non-authority to mitigate risks***: Community members complained about the r/Houston subreddit and viewed it as inadequate.

> It's almost like half of this sub has been shitposting, no official information. And this is 100% useless.

This prompted community members to solve the problem of not finding credible, authoritative information easily.

IT features: The Reddit platform offers several features such as hyperlinks, panels and security (read/write permission) for users for various purposes. Hyperlinks allow users to link to external content (e.g., Tweets) or other Reddit threads/comments, panels organise and display information and read-write security feature control who can view or modify content.

Actualisation of IT features to form new mechanisms: Some community members in the r/Houston subreddit aggregated information from authoritative sources relevant to Houston into a single 'livethread' mechanism. A livethread is a collaborative webpage provided by the Reddit platform designed for real-time updates where multiple contributors can actualise IT features such as hyperlinks and text to add short snippets of information. A livethread must be created as a separate group outside of the subreddit. The livethread is then populated with hyperlinks to information. When the livethread is linked to a Reddit subcommunity (e.g., r/Houston), it pulls information from the hyperlinks into the livethread page and presents information in reverse chronological order. Hence, viewers of the livethread do not have to click on the links to obtain information.

The livethread was configured with a main panel where the hyperlinks resided and a sidepanel. The side panel was populated with links to information deemed pertinent such as a checklist of what to prepare for in a hurricane by the Red Cross, a link to a

flood warning system map from the weather service centre and a link to a power outage tracker for Houston.

> For those of you still here, thanks for tuning in! I'm gonna do my best to keep this updated with information that will impact the Houston area. I've been updating the resources sidebar with additional links so please check that as well.

Governance system: Because the livethread was initially created outside of the subreddit, the livethread owner changed a configuration of a security feature (i.e., read/write permission) to restrict authorship. In this case, the livethread owner granted permission to a small team of volunteers to modify the livethread, and public access to everyone to read the livethread. The team identified information from official sources relevant to r/Houston. The consensus among the team was to focus specifically on the Houston metro area.

> 'We've decided to keep this Live thread going to keep it aligned with the Houston Metro area as best as we can' 'We'll continue here [livethread] and make sure everyone is up to date here on all the ongoings as they affect Houston'.

Reflexivity: Once created, a livethread (i.e., URL of the webpage) must be submitted to a subreddit and requires consent of a moderator to make it visible to the community. Since the livethread was created outside, it was not visible to the entire r/Houston community. Only a few community members recognised and shared the URL of the livethread with others who then followed it. However, community members lost track of the livethread because it was not easily noticeable. For example, one community member could not find the livethread the day following the hurricane.

> Thanks! Was following the livethread all night last night but it was off my feed this morning.

Recognition by authority: To solve this issue, the livethread owner submitted the URL of the livethread to r/Houston and asked for the moderators' consent to make the livethread visible to the community. Moderators recognised the potential of livethread and readily offered consent.

> Further thanks to the /r/Houston moderation team for enabling this livethread in the first place.

New sub-politics. ***Desire by authority and non-authority to mitigate risks***: Although the livethread was now available in the r/Houston community its visibility remained inconstant. Therefore, a few community members asked moderators to make the livethread noticeable.

> Can mods sticky this [livethread]? So, it's the first thing shown to any visitor.

IT features: One feature available to only moderators is the ability to 'sticky' threads or comments within a thread. Moderators can use the sticky feature to make critical information noticeable. A sticky thread appears at the top of a pile of threads regardless of its votes and time since posting.

Actualisation of IT features to optimise new mechanisms: However, a subreddit can only have two stickies (i.e., either two threads or a thread and a comment within the thread) at any one time. During that time, r/Houston had one sticky thread titled 'things to do this weekend', which had a list of events and places people could attend or visit. Following the suggestions from the community members, the moderators also stickied the livethread. Community members could now visit the livethread as a one-stop source of all relevant information about Hurricane Harvey pertinent to Houston.

New governance system: Any queries seeking official information were redirected to the livethread. It became an expectation that community members would use the livethread to seek official information instead of creating individual threads. For example, one member redirected another member to the livethread saying:

> /r/Houston livethread here: [link]. You can also find these from the stickied thread at the top of subreddit.

New reflexivity: The r/Houston community now followed this livethread. They obtained authoritative information pertinent to the Houston area from the livethread.

> I saw a comment or tweet in the livethread last night saying that we should reduce anything that puts water down the drain. This was due to a maxed out sewer treatment capacity.

Community members also showed their gratitude to the team of volunteers who contributed to the livethread. Difficulties in finding critical authoritative information were significantly reduced.

> I want to give a shout out to [the livethread ownername withheld], I saw him posting so many updates on the live thread. And any of the others that were working tirelessly on it. Good job yall. The things you write here have an impact far beyond reddit. They are passed along to friends in text, phone calls to aunts, and tweets to the area.

> Not to mention the numerous updates from the mayor that I wouldn't have seen otherwise. It meant a lot, thanks for your work.

We continued monitoring the r/Houston community after Hurricane Harvey ended. In recent times, the r/Houston community has experienced several other disasters (e.g., COVID-19 and The Great Texas Freezeout). The livethread is now routine and was resurrected for these other disasters (i.e., has been stabilised and used as a disaster-specific mechanism). We summarise the findings of vignette 1 in Figure 5 below.

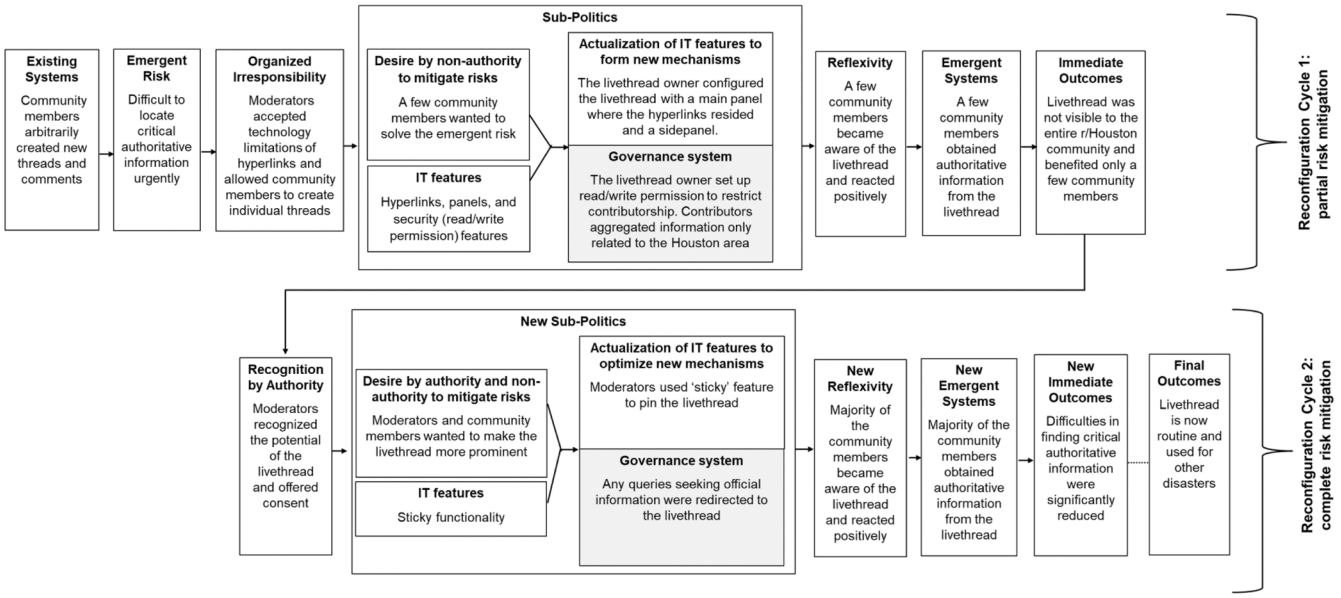

FIGURE 5 | Summary of Vignette 1.

4.2 | Vignette 2: Centralising Community Conversation

Emergent risk: In the midst of a disaster, community members need to be appraised of the most recent (hyperlocal) information relevant to their circumstances. However, large amounts of information were generated from both accurate and inaccurate sources.

IT features and mechanisms: Community members arbitrarily created individual threads or commented on existing threads to exchange information. They used several content publishing features (i.e., text, image, video and hyperlinks) to create threads or comments. Information exchanged included the current hurricane situation, the availability of drinking water, general advice and volunteer opportunities such as where to donate food and clothes.

> Hey guys, just wondering if there is a running list of stores that are open for groceries or food in general. I haven't been able to go out and search as our streets are flooded, and I'm sure other people are curious about the closures around them since some may not have prepared as extensively as they might have.

Community members also attempted to signal their concern by posting (i.e., by creating individual threads) short messages of assurance such as 'Stay safe'. However, the generation of multiple requests for information, offers of service and messages of assurance created a tragedy of the commons effect where the multitude of generated threads made it difficult to find useful information quickly. This was confounded by the large number of threads asking for the same information. Others would respond to these threads with conflicting or erroneous information. For example, one member created an individual thread asking if someone needed a boat for rescue but did not get any replies, even though there were people in need of such assistance.

> My brother has a boat and is ready to pick people up! Where can we find a list of people that currently need help?

Community members also created individual threads or commented on the existing one to find listed information (e.g., list of emergency numbers; pharmacies that were either open or inoperable; open shelters; and places seeking volunteers) and started blaming the moderators for not acting accordingly. Although some of this information (e.g., emergency number) was already available in multiple hyperlinks inside the livethread, community members wanted these to be compiled into a separate single thread.

> Why in the world are all the known emergency numbers not pinned in this subreddit? Can we compile all known emergency numbers in one [thread] and pin it already? Do we have mods on this subreddit? The community has been keeping everyone informed.

One member could not find a list of open places that someone had shared earlier.

> Does anyone have a list of places open in Montrose? I saw someone post a map yesterday, but can't find it now. I want to leave the house and see some other people.

Governance system: The existing virtual community system encouraged speaking about a wide variety of issues, and no issue was considered of higher priority than others, so no governance system was in place.

Organised irresponsibility: While the community members wanted a better way to find important information, r/Houston

moderators demonstrated organised irresponsibility by arguing the constraints of the social media platform (i.e., limitation of stickies) precluded them from organising the information in a better way.

> Reddit only allows for two stickied [pinned] posts [threads]. Complain to the [Reddit] admins, not the moderators.

Sub-politics. ***Desire by non-authority to mitigate risks***: Community members continued showing frustration. They wanted change because they could not urgently locate critical information. The livethread owner recognised the need for a dedicated thread for critical information.

> Why don't we have a dedicated thread just yet? wake up mods [moderators].

IT features: One way to get moderators' attention was by seeking community consensus. Reddit's voting feature allows the community to reach a consensus by upvoting or downvoting threads.

Actualisation of IT features to form new mechanisms: The livethread owner posted a thread asking the moderators to create a special single thread placed on top of the pile of threads (called a megathread) so all information would be collated in a central place.

> Fun times ahead. Hopefully the mod [moderator] team can create a megathread for the tropical storm? /u/ [moderator's name withheld]?

The default configuration on Reddit sorts threads based on popularity. Threads with the most upvotes become popular among other threads. Popular threads appear at the top of the pile. Multiple community members used the voting feature to upvote the request to create a megathread, which meant this thread continued to appear at the top of the thread pile. The moderators created a megathread with the title Yeah, this weekend is looking wet for Texas.

Governance system: No governance system was in place to indicate that it was a megathread and what community members could post in the megathread.

Reflexivity: Community members showed their gratitude to the livethread owner for proposing this solution. However, the initial megathread was not very successful. It did not clearly articulate that it was a megathread, and only a few community members obtained information from it. Furthermore, it was difficult to find the megathread as it was quickly buried under the mass of threads. As a result, many community members were still asking to create megathreads.

> I'm trying to stay up-to-date on things. I appreciate the sentiments, but I'd rather not have the sub [subreddit] fill up with junk posts [threads]. So, why not create a megathread?

Recognition by authority: The livethread owner highlighted the problem. As both moderators were outside Houston during the storm, they granted the livethread owner temporary moderator status.

New sub-politics (1). ***Desire by authority and non-authority to mitigate risks***: Every megathread on Reddit must be created by a moderator. Upon gaining temporary moderator status, the livethread owner began creating megathreads.

IT features: Every megathread has the following features: a title, a description box purportedly to describe what the megathread is about, and an initial post (i.e., the first comment). Moderators can also use other features such as 'sticky' to improve accessibility to these threads.

Actualisation of IT features to optimise new mechanisms: The livethread owner created megathreads for the first 2 days of hurricane. Each megathread was titled Hurricane Harvey Megathread (Day X). The description box was linked to the livethread. Thus, pertinent information relevant to that particular day was at everyone's fingertips. Recall that moderators can 'sticky' threads or comments within a thread and a subreddit can only have two stickies at any one time. The livethread owner stickied the megathread for the specific day (unstickying the previous day's thread).

He also stickied the initial post (i.e., the first comment) which contained the current up-to-date emergency instructions issued by authorities such that it always appeared on top of the megathread. The livethread owner also added further information in the initial post (i.e., the first comment) such as emergency numbers, a list of open shelters, evacuation routes and a link to an annotated Google maps with locations of important resources.

> Current civil emergency instructions right now: People escaping flood waters as a last resort, do not stay in attic. Call 911 for help and stay on the line until answered. If you need to be rescued, call 911 or USCG Houston Command Center at [contact number withheld]. Call Center numbers for emergency request and inquires: [contact numbers withheld]. List of open shelters: [listed information], Shelters and evacuation points: [listed information], Google Resources Map [annotated maps with locations of important resources].

Governance system: The livethread owner discouraged creating individual threads and redirected community members to the appropriate megathreads by saying: '*please post in Megathread, thanks*'*!*

New reflexivity (1): The existing moderation team returned to Houston on day 3 and took over creation of the megathreads. They copied the practice created by the livethread owner until the hurricane was over (i.e., the two stickies would be for the current day's megathread and the first comment within the megathread containing the public service announcement).

Community members recognised the new megathreads as an effective solution and started using them to obtain information. For example, one member suggested another member to seek information from the megathreads.

> There's a Harvey megathread stickied on the Houston subreddit. I would try there or ask there.

Difficulties in finding hyperlocal information were reduced. However, when community members visited the r/Houston community they could not see new information (thread or comment) first. This is because, the default configuration on Reddit (which r/Houston used) sorts threads based on popularity and sorts comments in a thread based on the ratio of upvotes to downvotes. Furthermore, community members could not differentiate between useful and not so useful information.

> People vote for visibility in situations as this that way important information goes to the top.

Recognition by authority: Based on community feedback, r/Houston moderators realised the ongoing struggle of community members to get the latest information and said: '/u/ [username withheld] we are looking into this now'.

New sub-politics (2). ***Desire by authority and non-authority to mitigate risks***: Community members argued that information in the megathreads is not sorted by how new or recent it is, making it hard to find the latest update. Moderators acknowledged the issue and attempted to solve it. They also wanted to find a way to differentiate between useful and not so useful information.

IT features: In Reddit, moderators can use the sorting feature to organise information in a particular order to maintain information timeliness. The Reddit platform allows one to apply different font transformations to text. It also allows moderators to edit others' comments.

Actualisation of IT features to optimise new mechanisms: Recall that by default, the ratio of upvotes to downvotes is used to sort comments. During Hurricane Harvey, moderators switched this so new comments were placed on top of the comments in the megathread. Thus, community members could see new information first.

> Not true. In this thread, sorting is done so that people see newer stuff first. Downvotes, upvotes don't matter much in this instance.

Governance system: During the hurricane, moderators played a role to curate and highlight important information. They went through comments in the megathread and highlighted in green what they perceived as important information. Community members scanning through the voluminous comments in the megathread could thus quickly pick out what was important.

> We have 2 spots to sticky things, that's it and there's a lot of stuff that would be great as stickies. That's why we're highlighting important lists green.

New reflexivity (2): Community members used megathreads as a primary source of information. For example, they obtained near-real-time information on water levels, road closures and open stores.

> This subreddit and these megathreads specifically have been a tremendous help not only for me, but for other guests in the hotel as well since it allows me to see basically in real time what areas are clear, what roads and stores are open, and so on, because despite the unprecedented storm, people still are foolish enough to want to venture out for whatever reasons.

Now, they could locate and identify useful information. Community member appreciated the efforts and commented that megathreads helped to keep themselves, family and friends safe.

> Thanks for your help running the megathread. As a Houstonian who was recently transplanted to Austin, your threads made sure that I could check up on my family and friends as they evaded hell and high water and keep them up to date if they were missing info.

We noticed that megathreads became routine and used for subsequent disasters (e.g., COVID-19 and The Great Texas Freezeout). We summarise the findings of vignette 2 in Figure 6 below.

4.3 | Vignette 3: Disclosing Personal Information

Emergent risk: Within r/Houston, strict anonymity was enforced. Community members could get banned for revealing their identity. During a disaster, this can be a problem for four reasons. First, if one is trying to be rescued or arrange to receive aid, one needs to reveal some identifying information (e.g., exact location). Second, community members are more likely to make insensitive statements if they are anonymous (Chen et al. 2016). For example, the following comment appeared in r/Houston:

> It's better if they die. Why should I have to treat a homeless patient who can't even swim? And not even get paid for it? If you care so much, take them into your home. Oh, don't want to? I bet you wouldn't even open the door if they were banging on your door. You hypocrite.

Third, community members can spread fake news without fear of repercussion. Such fake news on r/Houston included doctored photos of a shark swimming down the (flooded) freeway, and claims that: 'The city of Houston is shutting down water service'.

The presence of callous comments and fake news creates the final problem with anonymity. When someone posts genuine information, others do not know who or what to believe. For example, a meteorologist from Virginia shared real-time weather

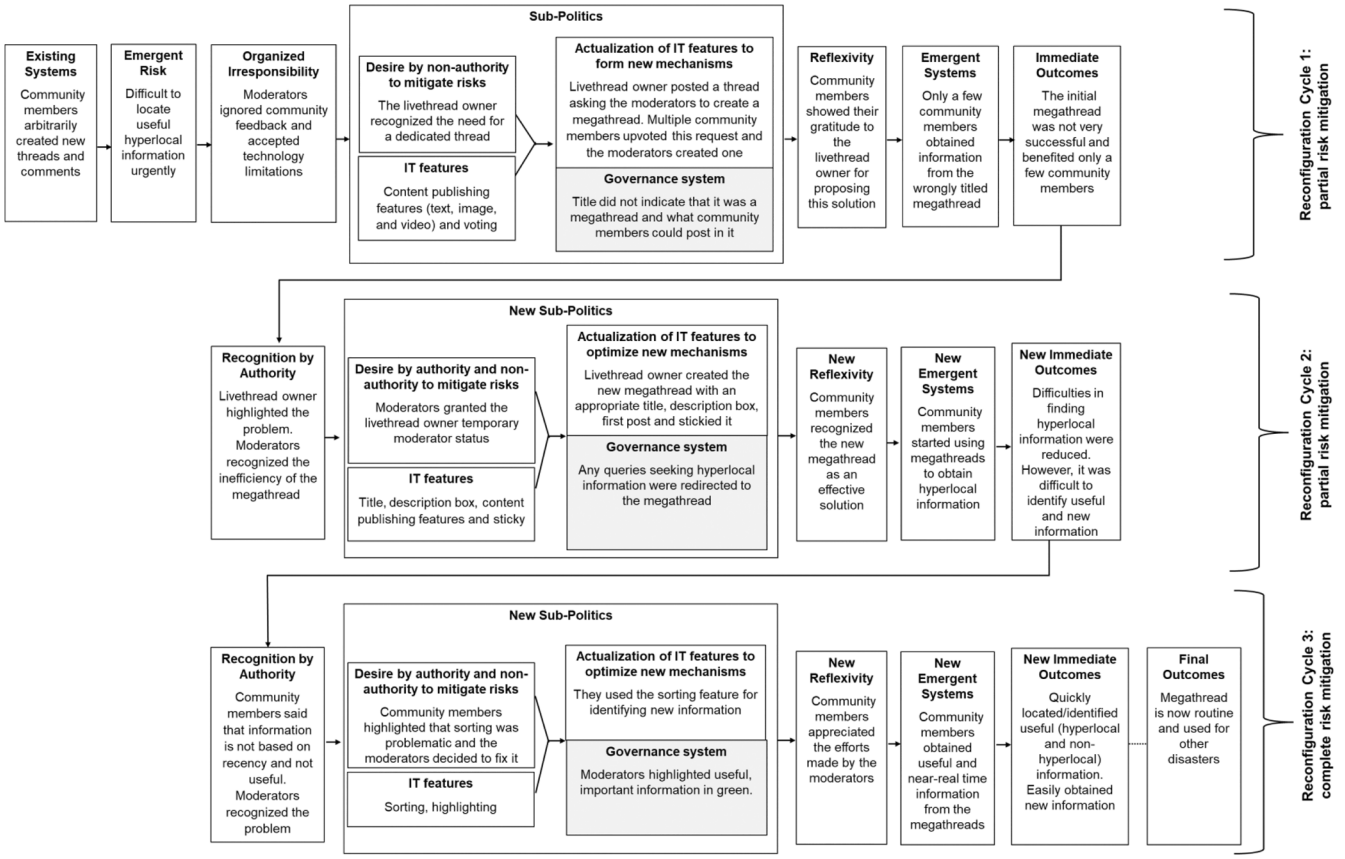

FIGURE 6 | Summary of Vignette 2.

updates and tried to explain some disaster models. Because community members could not verify the identity of the meteorologist, they questioned the veracity of his information. The meteorologist then had to explain the source.

> We are relaying data generated from weather modeling to raise awareness. I'm not making these weather maps up. Myself and everyone who follows these hope they bust, but the reality is people should pay attention when the ECWMF (Euro) makes such predictions.

IT features and mechanisms: Reddit identifies a user via a username which can be at best tenuously linked to a real person. Once a username is created, it cannot be changed.

Governance system: On r/Houston, community members had usernames that were not their real names and consciously removed their personal information and said: 'I'm going to delete my initial comment because, you know, personal information and the internet'.

Before the hurricane, r/Houston moderators enforced the practice of maintaining one's privacy by deleting any self-identifying (e.g., posting address or contact number) comments posted by community members. They mentioned the community rules: 'posting personal information, harassment, and other breaches are strictly forbidden'.

Organised irresponsibility: During the hurricane, moderators demonstrated organised irresponsibility in two ways. First, they strictly enforced community rules prohibiting posting personal information. They encouraged people not to disclose any personal information such as phone numbers and addresses.

> That's a lot of personal information being made public. Name, age, phone, addresses. Threat level.

Such moderation practices prevented people from seeking tangible help. Second, moderators did not devise mechanisms to address community concerns about the need for a way to find assistance and remove false information.

Sub-politics. ***Desire by non-authority to mitigate risks***: Some community members questioned such moderation practices and asked for justification. Other community members became dissatisfied and wanted to leave the community.

> I must say mods are dumb. Time to leave this sub [subreddit].

Given the problems with anonymity, a consensus emerged the anonymity practice should be relaxed.

IT features: Reddit platform provides a '@' tagging feature allowing users to mention others' usernames in a comment or post, drawing their attention to the specific content.

Actualisation of IT features to form new mechanisms: Community members used '@' tagging feature to tag moderators and suggested locals should be able to reveal personal information if necessary. For example, one member suggested to share zipcodes to indicate location: 'People should hashtag their zipcode so people with boats who are volunteering can filter who is in their vicinity'.

Governance system: Moderators agreed to relax rules on identity provision. Community members now could reveal their personal information without fear of repercussion.

Reflexivity: Community members appreciated moderators allowing them to post personal information. They started revealing their personal information such as their address.

> I have a friend in Kingwood who list (sp) power a day ago, and is out of contact... may need a rescue... does anyone know the situation there? Address is [house address].

Now, they could receive help from community members on the ground. For example, community members asked others to share their location for rescue purposes and for sending donations or relief directly to the victims.

> Can you share your address here or PM it to someone? They can post your location to the various rescue group pages on Facebook and get someone to your rescue hopefully!

While the relaxation on identity revelation addressed some community problems, the fact remained community members could remain anonymous which meant the second, third and fourth problem with anonymity (insensitive statements, false information and inability to verify real information) remained.

Recognition by authority: To solve this issue, community members suggested that there should be a way to signal community members' location or professional identity. Moderators recognised the problems associated with anonymity and were keen to address them but unsure how to do it.

New sub-politics. ***Desire by authority and non-authority to mitigate risks***: Community members requested that moderators create new flairs to indicate the location or signal the professional identity of community members. The revelation of one's professional identity can help convince others of the veracity of the information. For example, a professional meteorologist's words are typically assigned greater weight during a hurricane. The moderators agreed to create such flairs.

IT features: The Reddit platform offers a feature called 'user flair' by which moderators can label particular individuals as belonging to a group. User flairs can have custom text, images or both. When a community member adds a comment to a thread, the username and any associated flairs are attached to the comment.

Actualisation of IT features to optimise new mechanisms: Moderators reconfigured flairs (i.e., new flairs introduced). Below are some examples of the new flairs moderators created. Montrose is a Houston neighbourhood, commonly called the 'Heart of Houston'. The new flairs were then integrated into the megathread.

Posted by u/username/ Former NRL Meteorologist ⟸ *flair*

Posted by u/username/ Montrose ⟸ *flair*

Governance system: It became an expectation that community members would use new flairs to indicate their location, and moderators would label particular individuals to reveal their professional identity (e.g., meteorologist).

> If you are on desktop, go to the subreddit you can request a flair for your area.

New reflexivity: Community members recognised the value of the flairs during the disaster and asked others to obtain one: 'people, make sure you have flair, we need to know where you are'.

The introduction of new flairs improved the credibility of given information and reduced falsehoods. It created new norms within the r/Houston community. A trust premium was awarded to community members who revealed themselves, who could be identified as living in Houston or who were identified as having a disaster-relevant profession.

> I relied on you guys in throughout, and you [locals] gave reliable, on the ground, information, for all of us struggling to figure out which areas were about to get flooded. r/houston = best coverage of this whole shitshow!

Moderators created new flairs for subsequent disasters (e.g., COVID-19 and The Great Texas Freezeout) and community members wore them. For example, they created flairs for health professionals during COVID-19. We summarise the findings of vignette 3 in Figure 7 below.

4.4 | Vignette 4: Regulating Community Conversation

Emergent risk: During the hurricane, many community members started following the r/Houston subreddit for the first time, but many of these were not from Houston. Before the hurricane, the r/Houston subreddit welcomed all kinds of discussion related to Houston including political conversations. Anyone could also make unsubstantiated claims. The moderators did not explicitly specify any rules regarding posting unsubstantiated claims. However, when an unsubstantiated claim is false, people in a disaster can make potentially fatal decisions. Furthermore, unsubstantiated false claims can crowd out or make it harder for people to obtain correct information. For example, some community members commented that they had 'heard' from their friends that some roads were dry whereas these were actually flooded and vice versa.

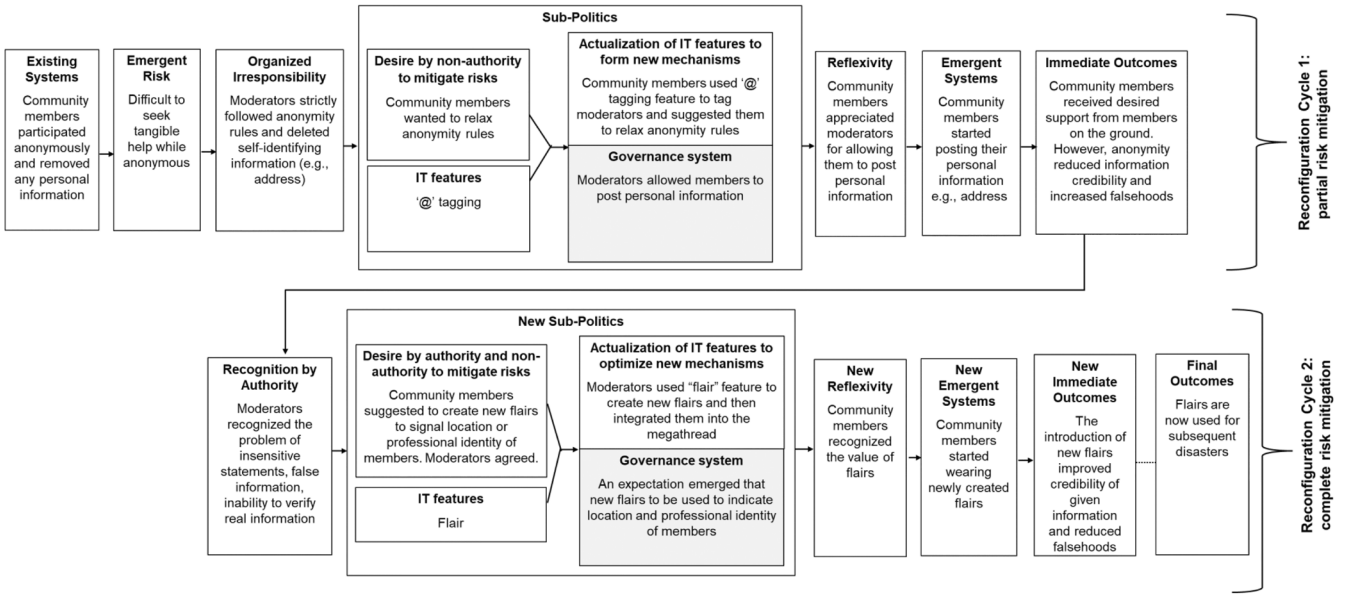

FIGURE 7 | Summary of Vignette 3.

IT features and mechanisms: During the disaster, many fake and unsubstantiated claims were posted. Community members used the cross-posting feature to share unreliable information during the hurricane (including in the megathreads). The cross-posting feature allows community members to take a thread from one subreddit and share it with the same or another subreddit. They can also use the cross-posting feature to share information from other external sources (e.g., Twitter). Many community members found this kind of conversation unhelpful and questioned the veracity of given information. For example, a community member commented:

> What is your "reliable source"? Clear Lake City Water Authority issued a statement that rumors on social media that the water supply is threatened are false.

Governance system: Everyone was able to contribute, and no discrimination was acceptable. No governance system was in place to detect unsubstantiated claims except for community members questioning the veracity of given information. Making unsubstantiated claims and sharing unreliable information led to wrong actions (e.g., legitimate information was downvoted). Rumours were rife.

Organised irresponsibility: The moderators demonstrated organised irresponsibility by allowing conflicting and unreliable content to be shared in the community. They mainly relied on AutoModerator to detect spam posts.

Sub-politics. ***Desire by non-authority to mitigate risks***: Community members continued showing their frustration towards moderators for inactive patrolling and said: 'Well, this sub was helpful for a while. Now it's a bunch of political shitposting by outsiders. The mods always sucked on this sub. Stay safe'.

To combat the problem of unsubstantiated claims and unreliable information, community members began suggesting any informational comment be backed by evidence (e.g., an image or a video) or by a link to official source.

IT features: Users can attach multimedia files (e.g., image, video or a website link) on Reddit threads or comments.

Actualisation of IT features to form new mechanisms: The provision of evidence was enabled by features such as being able to attach multimedia files (e.g., image, video or a website link). Besides, community members began to use Reddit's voting feature (i.e., upvote or downvote) to indicate which information was useful.

> Yeah, reports from reliable sources are good to share. Rumours and news circulating solely on social media are spreading a lot of unnecessary distress.

Governance system: It became a norm to attach evidence when creating informational comments. Furthermore, evidence-based informational comments were given many upvotes, while those without evidence were downvoted.

> I repeat stop asking questions here there is only two acceptable comments in this thread that won't get you downvoted: 1. Picture/description of where water is. 2. Some sort of caring "stay safe friends" comment.

Reflexivity: Community members realised the importance of attaching supportive evidence. They started providing evidence such as pictures or a link to official sources while seeking help or giving information. Others found this evidence useful and appreciated those who provided it and said:

> Thank you for actually posting evidence instead of telling people to go find it.

The emergent norm of attaching evidence improved the credibility of given information. However, many problematic community members (particularly outsiders who had no local knowledge) continued discussing irrelevant issues (e.g., politics) and trolling others. For example, they criticised the mayor for not issuing an early evacuation notice because he was a Democrat (one of the two major American political parties). However, community members contradicted this claim and urged everyone to stop dragging politics into the community discussion.

> We're not democrats or republicans right now. We're goddamn Houstonians. And above that we are Texans... Please don't update the Houston thread with the fight at this time.

Recognition by authority: Community members suggested that moderators exclude problematic community members and remove irrelevant information. Moderators became aware of their concerns.

New sub-politics. ***Desire by authority and non-authority to mitigate risks***: Both community members and moderators agreed to mitigate risks associated with problematic members and irrelevant information.

IT features: On Reddit, the 'Report' button feature allows users to flag threads or comments that they believe violate Reddit's policies or the specific rules of a subreddit. If content is repeatedly reported, it is usually reviewed by the subreddit moderators. Furthermore, subreddit moderators have 'mod tools' features at their disposal to help keep a subreddit on topic and safe. Mod tools offer various functionalities that help moderators handle tasks such as reviewing threads and comments, managing community members and taking actions such as banning community members and removing content.

Actualisation of IT features to optimise new mechanisms: Community members reported irrelevant content and problematic community members by using the 'Report' button. For example, one member reported insensitive comments to moderators for removal and said:

> I reported their comments for being vulgar and offensive. The mods might have also taken it down.

Now, moderators began to recognise the need for active patrolling. r/Houston moderators started policing the megathreads by removing inflammatory, irrelevant comments and fake news. They advised community members to redirect their questions to the appropriate megathread and also used mod tools feature to ban community members who tried to propagate rumours and fake news.

> Hey /r/houston, we've been cleaning out a lot of stuff from the subreddit to try to keep more important info at the front page... General questions are still best posted in the megathread discussion! It's super active and sorted by new so your stuff gets seen.

Governance system: It became an expectation that every community member would report misleading information to moderators for removal. Moderators would take on more active role to review both posts and offending community members.

New reflexivity: The active patrolling of the megathreads meant irrelevant content (e.g., political statements) and socially unacceptable behaviour (e.g., trolling) was greatly reduced. Community members appreciated the efforts made by the moderators for keeping relevant information flowing.

> The mods have and still are doing an absolutely amazing job and I can't thank them enough who did all of the pertinent information upkeep.

Community members became mindful when sharing any information. They sought evidence-based informative information from locals.

> Please check with locals before you return to [address]. You may be more helpful somewhere where you have electricity and working phone/internet and can maybe help others.

Subsequently, it has become a norm in the r/Houston community to attach evidence when making claims or sharing information and upvote evidence-based information during a disaster (e.g., COVID-19 and The Great Texas Freezeout). We summarise the findings of vignette 4 in Figure 8 below.

5 | Discussion

During a disaster, virtual communities have the option to reconfigure themselves (Boh et al. 2023) to mitigate emergent risks. However, how virtual communities can reconfigure themselves has remained an open question. Hence, we have sought to answer the following research question: *How can virtual communities reconfigure themselves to respond effectively to a disaster?* Our findings suggest this reconfiguration involves a series of cycles involving (1) virtual community members (non-authority) during the initial cycle and (2) the cooperation between non-authority and moderators (authority) in the subsequent ones. The first reconfiguration cycle involved virtual community members wanting change as their urgent informational needs were not being met. However, there was organised irresponsibility by authority. In most of our vignettes, organised irresponsibility manifested as moderators arguing the IT features did not allow for the changes requested by the community. In vignette 1, moderators suggested limitations of the way threads could be stickied. In vignette 3, moderators had a fixed mindset and did not relax rules for revealing personal information. In vignette 4, moderators relied on existing mechanisms (AutoModerator) that were unsuitable during a disaster.

In the one vignette where moderators embraced a configuration to attempt to manage the disaster (vignette 2), they did so incorrectly. They created a megathread with inappropriate sorting

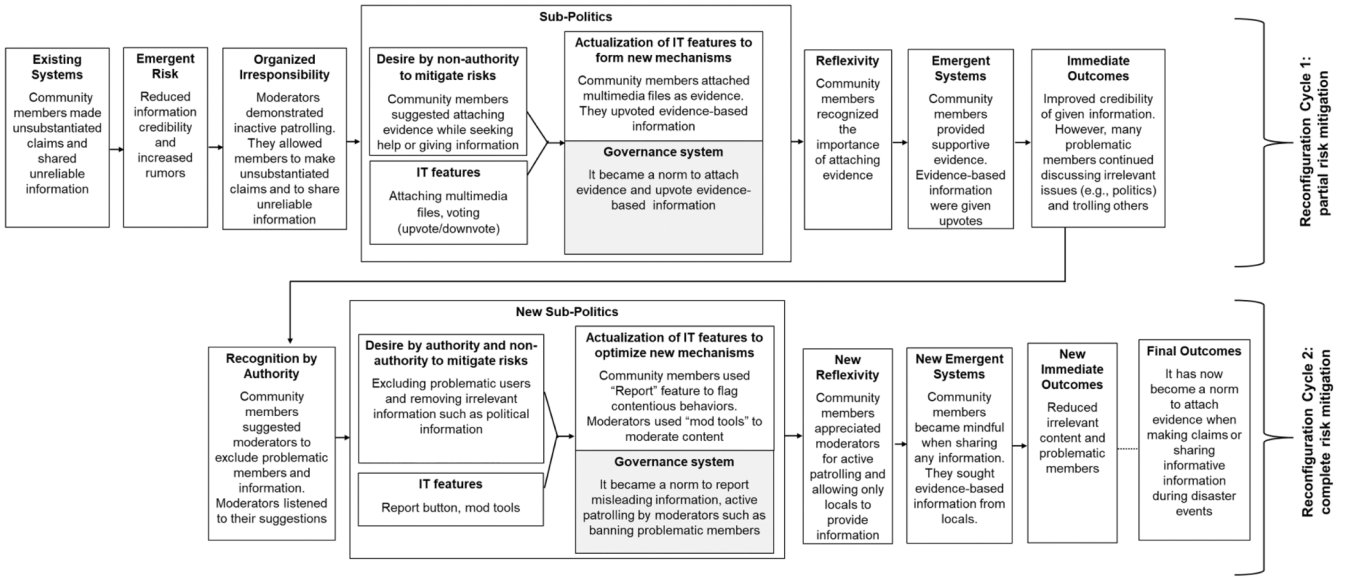

FIGURE 8 | Summary of Vignette 4.

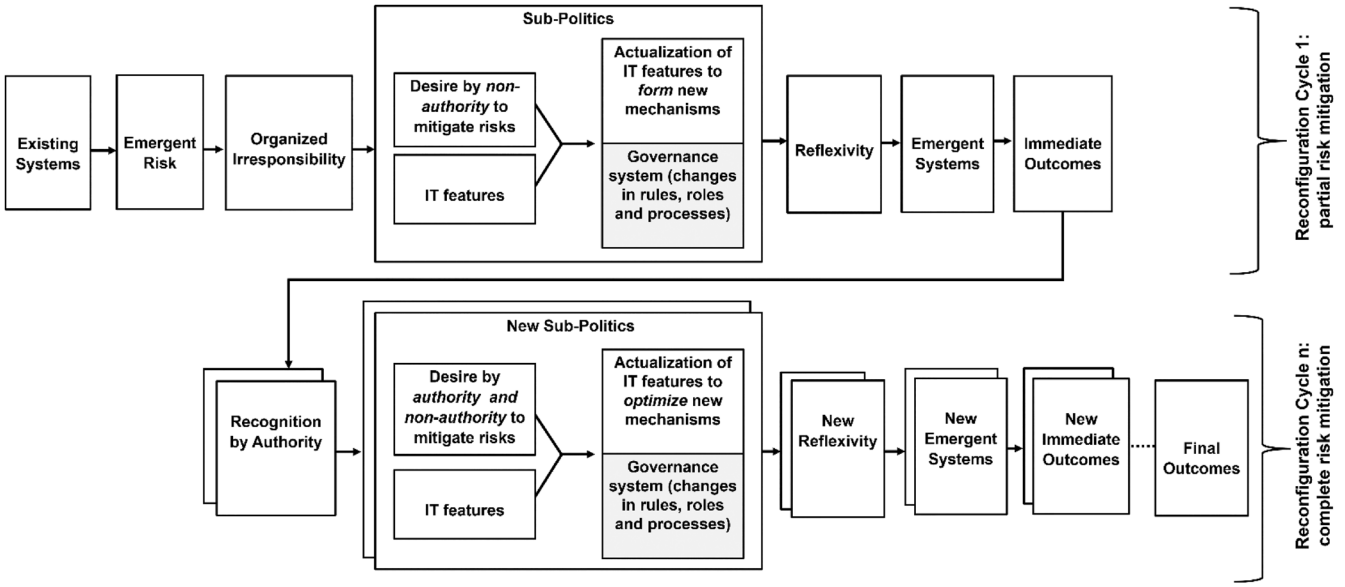

FIGURE 9 | The risk mitigation process through reconfiguration cycles.

criteria and a name that did not attract the correct kind of attention. This led to the emergence of sub-politics driven by community members' desire for change. Interestingly, sub-politics manifested as new configurations of IT features into new mechanisms. In vignette 1, this was the livethread. In vignette 2, a temporary moderator was appointed who created an appropriate megathread. In vignette 3, zipcode hashtags emerged. In vignette 4, a stylised structure for reporting information (e.g., providing image or video evidence) emerged.

During the ensuing reconfiguration cycles, moderator thinking changed. This was because moderators became aware of how IT features could be configured into appropriate mechanisms for two reasons. First, they could see the material presence of a mechanism (e.g., a livethread or megathread) and second, they could witness the success of the mechanism, at least on a small scale. This led to the emergence of new sub-politics, as there was a desire by both moderators and community members to bring about change. IT features were actualised to optimise the mechanisms while fresh governance systems were put in place. For instance, the 'sticky' IT feature was used to pin the livethread, while the norm of redirecting people to the livethread for official information was developed. The reconfiguration cycle repeated until the particular risk was fully mitigated. This common pattern was observed across the four vignettes. Figure 9 below illustrates our risk mitigation conceptual framework, focusing on how reconfiguration occurs. Table 5 summarises our findings.

Our results suggest multiple reconfiguration cycles are necessary to mitigate risks. In every case, entrenched moderators *failed to envision the reconfiguration of IT features and governance systems* required to adapt to the disaster. They were anchored in pre-disaster routines and prevented the adaptation of existing

TABLE 5 | Summary of findings.

Vignette	Community needs and priorities during normalcy	Existing (pre-disaster) systems	Community needs and priorities during the disaster	Moderator's initial action (Organised irresponsibility)	Sub-politics (Actualisation of IT features to form/ optimise new mechanisms; changes in governance system)	Emergent (disaster-time) systems
The need for collated authoritative information	Everyone had their opinion and valued equally	Open information hub - *arbitrary creation of threads and comments*	Expert opinion and information from authoritative sources were more valuable and should receive greater prominence	Moderators claimed limitation of hyperlink IT feature. Did not consider a solution where authoritative hyperlinks were collated in one source	◈Went outside the r/ Houston community to create livethread, that is, a single source of authoritative links ◈ Sourced authoritative information that fits the local context ◈ Only a restricted set of community members could update the livethread	Controlled information hub - *centralisation of information*
Centralising community conversation	Community allowed discussing diverse topics (e.g., politics, entertainment and sports)	Open information hub - *arbitrary creation of threads and comments*	Topics about the disaster should have more prominence than everything else	◈ Moderators claimed limitation of stickies, implying multiple topics were of equal weight to be stickied ◈ When pressured to create a megathread, moderators created one with a neutral name	◈ Livethread owner was granted temporary moderator status ◈ Disaster megathread given a prominent name and stickied ◈ Certain information (hyperlocal, authoritative, important contact) always given prominence over everything else	Controlled information hub - *centralisation of information* - *curation of information*
Disclosing personal information	Privacy (e.g., personal information such as address) was respected and strictly maintained	Identity safeguarding - *community members used pseudonym to remain anonymous*	Personal information needed to be sacrificed to help community members in need	◈ Initial policy was to not give out personal information ◈ Initially, moderators sanctioned for doing so	◈ Community members pressured moderators to allow personal information to be revealed ◈ Concept of flairs disclosing location and professional status introduced	Identity revelation - *disclosure of personal information* - *identity signalling*

(Continues)

TABLE 5 | (Continued)

Vignette	Community needs and priorities during normalcy	Existing (pre-disaster) systems	Community needs and priorities during the disaster	Moderator's initial action (Organised irresponsibility)	Sub-politics (Actualisation of IT features to form/ optimise new mechanisms; changes in governance system)	Emergent (disaster-time) systems
Regulating community conversation	Discussions should remain respectful and inclusive. Everyone was able to contribute, no discrimination was acceptable	Open information hub - *arbitrary creation of threads and comments* - *some community members cross-posted unreliable information from external sources*	Community members physically in Houston and community members with special skills were more important than others. Proof of worth was mandatory to speak	◈ Initially, moderators mostly relied on AutoModerator to curate contents. However, it failed to differentiate between reliable and unreliable information	◈ Flairs introduced ◈ Strict requirement to attach evidence when making factual statements ◈ Moderators started active patrolling. Community members who created falsehoods, tried to make a profit, had no local knowledge etc. persecuted	Identity revelation - *disclosure of personal information* - *identity signalling* Controlled information hub - *curation of information* - *attaching supportive evidence*

systems. Moderators would either claim the existing IT features did not allow for reconfiguration or a new configuration was not suited to the disaster situation. This lack of foresight led to delayed responses, propagation of irrelevant information, falsehoods and dissatisfaction among community members during the disaster. Sub-politics driven by community members thus emerged, meaning that they successfully advocated for necessary reconfigurations during the disaster.

Unfortunately, the initial round of reconfiguration was often beset by problems arising from the moderators' inability to understand the reconfiguration. In vignette 1, the livethread could not obtain prominence before it was stickied. In vignette 2, the successful megathread was contingent on a temporary moderator. In vignette 3, hashtags were difficult to search for, and in vignette 4, structured posts required everyone to conform to the rules of the structure. A second round of the risk society process had to take place where the existing moderation team understood the reconfiguration and demonstrated support for it. In vignette 1, moderators stickied the livethread. In vignette 2, moderators enacted the megathread practices the new moderator showed them. Moderators also highlighted salient data in the megathread in green. In vignette 3, moderators no longer sanctioned community members for posting personal information and created flairs for revealing personal information. Finally, in vignette 4, moderators enforced the new rules in favour of evidence. This second round cemented the reconfiguration's place in the community.

The livethread, megathread and flairs became new disaster-specific mechanisms. During the regular functioning of r/Houston, these mechanisms are backgrounded. However, subsequent to this case, r/Houston has faced many disasters, including COVID-19 and the Great Texas Freezeout. During the latter, Houston's electrical and water systems failed during extreme cold weather (by Texas standards). During these disasters, these mechanisms became foregrounded as community needs and priorities changed.

The above observations lead to the question of why sub-politics is necessary and why entrenched authority cannot envision new configurations. We argue that while a new configuration is comprehensible in retrospect, at the time it is only comprehensible when it becomes material (i.e., physical) reality. When a mechanism has no material presence (i.e., it has not been created yet), it is merely one of a near infinite possible configurations of IT features. Furthermore, a configuration does not function by itself, but instead must be embedded in a system where rules, both formal and informal, are established, and people are assigned to or volunteer for roles. A person embedded in a disaster can see an endpoint, a solution to a problem, and works backwards to understand what a feasible configuration might look like. However, a moderator removed from the disaster does not see the specific endpoint, but only a myriad of possibilities; the 'correct' reconfiguration is not immediately visible. We can see this best in vignette 2. Megathreads were described to moderators who understood the mechanics of the megathread but failed to implement them in a useful way. Furthermore, moderators are anchored to existing practices. For example, the moderators perceived anonymity and free expression as good, failing to realise that in the specific context of a disaster, these policies

make receiving assistance impossible. The 'correct' reconfiguration is perceived as contrary to these existing beliefs and thus rejected out of hand.

In such a situation, especially given time pressure, it is difficult to explain to a moderator what an appropriate configuration is and the associated appropriate governance system. Instead, the introduction of a configuration with observable material properties, that is, an artefact, is a more powerful way to obtain moderator understanding. Indeed, this is what happened in every vignette. Moderators failed to grasp the configuration possibilities, but once shown the configuration, moderators moved to implement it.

5.1 | Theoretical Implications

Our research aims to contribute to the IS literature and disaster management discourse in several ways. First, while prior IS research has acknowledged risk society as a theory relevant for information systems (D'Mello 2005; Dwyer et al. 2021; Jacucci, Grisot, and Hanseth 2004; Westergren and Holmstrom 2008), to our knowledge no one has leveraged its key theoretical insights. Prior IS research does not explain how virtual communities can simultaneously fulfil emergent needs while suppressing emergent risks during times of disaster (e.g., Nan and Lu 2014; Lu and Yang 2011). Drawing on the perspectives of risk society theory, this study sheds light on how virtual communities create, distribute and mitigate risks by reconfiguring themselves during disaster. We also illustrate the role of IT features in increasing or reducing risk. Particularly, we show how organised irresponsibility stems in part because of an inability to visualise configurations of IT features. Materialising IT features helps reflexivity and changes the trajectory of sub-politics. During a hurricane, existing mechanisms available in the virtual community created risks for its community members in addition to those created by the hurricane itself. These risks were mitigated by reconfiguring IT features to create disaster-specific mechanisms. Our conceptual framework (see Figure 9) explicitly shows the role of IT features in risk society theory, therefore answering the call from Morton, Zorina, and Kudaravalli (2023) to uncover what configurations of IT features are effective in virtual communities during disasters.

Risk society theory primarily considers sub-politics as a domain where non-authority brings about change (Beck 2009; Wynne 1996). The theory pays limited attention to the interdependency of social actors, particularly non-authority and authority, in the production and mitigation of risk. Our findings show that risk cannot be fully mitigated by non-authority alone, which in our case were virtual community members. Instead, it requires a series of reconfiguration cycles, initially involving community members to create new mechanisms and governance systems, and subsequently collaborating with authority (i.e., moderators) so that the mechanisms are absorbed and institutionalised in the virtual community. In part, this is because certain IT features (e.g., stickies) are only available to those with the required permissions. As such, we contribute to the ongoing discourse on sub-politics (Beck 1992; Beck, Giddens, and Lash 1994; Chan 2008) by demonstrating the interdependency of non-authority and authority in risk mitigation. We suggest that sub-politics is not just an area for non-authority, but also requires the willingness of authority to bring about change.

Second, in contrast to the current views of reconfigurability involving just IT features (e.g., Boh et al. 2023; Freitas et al. 2017), we show it also involves human aspects. In this research, we show configuration has at least two parts, people having a vision of the configuration and the IT configuration itself. We also show that this vision of configuration is non-obvious. Some can see it, but many cannot. In our vignettes, each mechanism was within the power of the moderators to create. Thus, reconfiguration was not about the mechanical properties of the IT features. Non-authority figures needed to create the mechanisms which the moderators could then see and support.

We thus demonstrate that a successful risk mitigation process requires more than just access to IT features—it also requires human ingenuity (i.e., the ability to envision effective solutions to a problem). Our findings suggest that both the IT features must be reconfigurable and virtual community actors (i.e., community members and moderators) must be able to envision how the IT features can be configured to address the risk. Furthermore, they must envision the governance system required to make the new configuration effective. Introducing new configurations without a revised governance system could lead to potential conflicts or inefficiencies due to the misalignment of expectations.

This leads to our third insight. Entrenched leaders are often unable to envision the new configurations and governance systems for two reasons: they are anchored in existing routines and lead from a distance. Our research thus unearths the importance of hyperlocal leadership in virtual communities in times of disaster. Virtual communities are often not physically geolocated (Faraj et al. 2016; Lu and Yang 2011), and thus, leadership is often based on other criteria, such as those willing to volunteer their time (Faraj, Kudaravalli, and Wasko 2015; Johnson, Safadi, and Faraj 2015). However, because disasters are often geolocated, *geolocation* becomes a critical element required of a leader. Only a hyperlocal individual experiencing the disaster understands the changing community needs, and thus, only a hyperlocal individual can envision the IT reconfiguration and governance system required. For example, in vignette 1, a group of hyperlocal community members monitored the on the ground situation, acknowledged the extent of the disaster and created an appropriate information hub (i.e., the livethread). Not being hyperlocal means one might not understand the situation on the ground.

Finally, we also contribute to the disaster management literature. Our findings contradict prior literature, which suggests engaging with institutionally unembedded actors can cause decision paralysis, hinder fast information sharing and promote ineffective resource coordination (Neal and Phillips 1995; Schneider 1992; Siegel 1985). Official disaster leaders tend to ignore hyperlocal actors and do not tolerate any interference with their planned activities (Majchrzak, Jarvenpaa, and Hollingshead 2007; Twigg and Mosel 2017; Whittaker, McLennan, and Handmer 2015). However, our case study has demonstrated that authority should recognise emergent hyperlocal leaders from the virtual

community and cooperate with them for effective disaster response. They should temporarily cede leadership to emergent hyperlocal leaders so they can reconfigure the IT features along with virtual community systems (mechanisms and governance systems).

5.2 | Practical Implications

Our study has several practical implications for virtual communities, emergency authorities and system designers. Our study suggests virtual communities can reconfigure themselves by incorporating the following changes to their design when disasters occur:

First, we suggest that community members, particularly those on the ground (i.e., hyperlocal) should play a pivotal role in mitigating risks. We recommend these hyperlocal members should create and demonstrate new mechanisms (e.g., livethread). Our findings show that without the initial desire and work of community members to reconfigure IT features (i.e., sub-politics), risk cannot be mitigated. The reason is that the moderators in our case were blindsided and could not envision how to actualise the IT features in the right way.

Second, we also recommend community members work collaboratively with moderators to institutionalise the mechanisms and governance systems. Without this step, risk will be partially mitigated and only a few disaster victims will receive helpful information. In practice, community members need to physically show moderators how new mechanisms work. Once mechanisms and their associated governance systems are absorbed into the virtual community, community members are encouraged to support it for wider acceptability and use through reflexivity.

Third, virtual community moderators should centralise the flow of information. This makes it easier for both virtual community leaders and community members to process and extract the most salient information during a disaster. They should actively curate information and keep important information visually on top of the community discussion board. Virtual community moderators should only allow individuals who can provide relevant information to post. During times of disaster, community members are overwhelmed and cannot easily find information upon which they can act. Thus, one potential key role of virtual community moderators is to develop new mechanisms that aggregate information from both authoritative and hyperlocal sources. In our study, hyperlocal volunteers aggregated authoritative information in a single thread (megathread). This approach made information visible and quickly accessible for community members.

Fourth, during times of disaster, virtual community moderators should establish community norms that informational threads must be evidence-based. Fake information not only burdens emergency response but also leads to an increase in public anxiety. Allowing only trusted information to propagate reduces the amount and impact of fake information. Community platforms should include IT features (e.g., voting and reporting) to counteract fake information. For example, in our study, community members used a voting IT feature to indicate fake and irrelevant information. They also used a reporting IT feature to exclude problematic community members.

Fifth, virtual community moderators should change policies promoting anonymity during disasters. Although prior crisis response research suggests respecting privacy (Kaufhold et al. 2019; Yates and Paquette 2011), we suggest virtual community moderators should allow community members to disclose identity and personal information during a disaster. Identity revelation can foster trust and encourage more reciprocal behaviours. It is also necessary if community members need assistance. We realise that our recommendation to change policies promoting anonymity goes against respect for privacy. Once one's identity is revealed, there is no going back. However, when confronted with the life-or-death situation of a natural disaster, community members may choose to prioritise staying alive above privacy considerations. We believe they should at least be given a choice if they want to reveal their identity and location during a disaster. For example, in our study moderators relaxed anonymity rules, allowing community members to disclose personal (e.g., address) and professional identity information. Community platforms should also include IT features (e.g., badge) signalling the identity of community members.

Sixth, consonant with previous studies, our research shows the importance of emergent leadership. We found effective emergent leaders during a disaster were always hyperlocal individuals (i.e., community members on the ground). Once identified, virtual community moderators should cooperate with them (i.e., creating a shared vision) and grant them power (e.g., endorse temporary moderator status). In our study, moderators granted power to the livethread owner (i.e., a hyperlocal individual) who took responsibility for the megathreads. Community platforms should thus include IT features to identify potential hyperlocal moderators and facilitate their contributions (e.g., based on frequency of interaction, location).

Lastly, our research suggests that existing government and disaster-focused emergency organisations (e.g., incident management officials, law enforcement agencies) should actively collaborate with virtual communities. Official information should be made easily accessible to virtual communities, for example, through an open application programming interface (API). At the moment, such information is often only made available in difficult-to-process forms such as web or Twitter announcements. Disseminating such information in an API would make it easier for virtual communities and other frontline/first-responders to better respond in particular hyperlocal situations. Table 6 summarises our suggestions for practice. Future research could investigate taking a design science approach to examine how an API could be developed to improve data accessibility.

6 | Limitations and Future Research

We acknowledge various limitations of our study. First, ours is a single case study focused on a specific disaster (i.e., Hurricane Harvey). Therefore, our findings illustrate just one possible,

TABLE 6 | Suggestions for practice.

Stakeholder	Suggestions for practice
Virtual community members	- Create and demonstrate new mechanisms - Enable moderators to witness the potential of new mechanisms - Support mechanisms and governance systems for wider acceptability and use
Virtual community moderators	- Centralise the flow of information so the information is easy to find - Establish new mechanisms that aggregate information from both official and hyperlocal sources - Actively curate information and keep important information visually on top of the community discussion - Establish norms that informational threads must be evidence-based (e.g., a link to official sources) - Allow community members to reveal their identity and personal information so they can get desired social support (e.g., rescue and donations) - Recognize and cooperate with emergent hyperlocal leaders for effective disaster response
Emergency authorities	- Actively collaborate with virtual communities - Make official information easily accessible to virtual communities (e.g., through an API)
System designers	- Include IT features (e.g., badge) to signal the identity of community members - Include IT features (e.g., frequency of interaction and location) to identify potential hyperlocal leaders - Include IT features (e.g., voting and reporting) to reduce falsehoods and problematic community members

effective response to a disaster; perhaps, other responses could be just as if not more effective. Although we cannot generalise our findings to a population (Lee and Baskerville 2003; Walsham 2006), like all qualitative studies we have generalised our findings to a theory, in our case that of the risk society. The proponents of this theory argue that contemporary society organises itself in response to risks, many of which are human-generated. We have shown that many of the risks that emerge during a disaster are indeed human-generated. People organised themselves on the r/Houston subreddit in response to these risks.

Second, disaster scale and scope are likely to have significant impacts on how people attempt to mitigate emergent risks (Majchrzak, Jarvenpaa, and Hollingshead 2007). A disaster can be short-lived (e.g., earthquakes) or prolonged (e.g., pandemics). Our study focused on a disaster of relatively short duration (in days) where the social media platform—Reddit and its features remained constant. The duration of a disaster may influence how it is managed. From an information technology perspective, new technologies, IT features and innovations can be introduced for prolonged disasters. For example, during COVID-19, certification apps emerged to verify peoples' immunisations. Future research could investigate how disaster duration impacts disaster responses. Additionally, it could examine the closeness or relationships between institutional (e.g., governments) and non-institutional actors (e.g., the general public and community organisations), shedding light on how trust and shared responsibilities evolve during disaster response efforts. The various components in our proposed framework (Figure 9) must be explored across multiple contexts, thus requiring further research and development. We encourage future research to test our proposed framework in other disaster contexts or build on ours to enrich our theorisation.

A third limitation is that our data originated from a single communication platform (i.e., Reddit). Other platforms may provide different IT features which could trigger the community to form new mechanisms and governance systems. We thus encourage future research to investigate other communication platforms (e.g., Twitter, Facebook and Digg). We also acknowledge that our study only focuses on the disaster response period. However, mechanisms and governance systems in virtual communities may evolve with time. As we mentioned earlier, the livethread, megathread and user flair practices have evolved in the r/Houston community since Hurricane Harvey.

7 | Conclusion

This study has examined how virtual communities can reconfigure themselves to manage risks during disasters. Reconfigurability involves both human and IT aspects. Just as IT features can be constrained to make certain kinds of configuration impossible, so humans can likewise be constrained. For reconfiguration to be successful, the right person must be given access and allowed to reconfigure things. During a disaster, we argue the right person must be a hyperlocal community member. Practically, our case study of a virtual community during Hurricane Harvey has identified several mechanisms that facilitate the successful management of disaster information. We have shown that virtual communities should recognise changing community needs and priorities, envision and reconfigure IT features, envision the surrounding governance system, discriminate towards hyperlocal community members and defer to emergent leadership.

Data Availability Statement

The authors collected archived data from Reddit social media platform, which is publicly available online. Therefore, others can validate the data sources.

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