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THE ROLE OF SOCIAL MEDIA IN DISASTER COMMUNICATION:

THE CASE OF HURRICANE HARVEY

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Abstract

Social media accompany people in their lives, going beyond the sole purpose of entertaining and maintaining contact. Instead, the social media increasingly complement and replace the role of traditional media regarding rapid distribution of breaking news and introduce a new collaborative two-way form of communication. It is therefore inevitable for the public sector to implement this new media in all areas, one of them being disaster management and communication. With the help of a comparative analysis, this research investigates *to what degree official disaster response communication guidelines and the social media activity of public institutions during disasters take the increased need for social media communication into account* with a single case study. Data from relevant government documents were compared and related to Twitter data, produced during Hurricane Harvey in August 2017. Among others, methods like an Social Network Analysis and Natural Language Processing made the raw Twitter data utilizable. The main findings of this study are that the official guidelines and the Twitter activity of public institutions in the case of Hurricane Harvey do not sufficiently consider social media as part of disaster communication. This results in recommendations for policy- and decision-making in the field of disaster management, such as the involvement of the National Hurricane Center or the clear formulation of tweets.

Content

Chapter 1: Introduction

Today's world is confronted with an increasing number of disasters such as floods, hurricanes or landslides. The United States alone had to witness 16 natural disasters in 2017 (Pierre-Louis, 2018). Besides the self-evident approach to significantly reduce this number of disasters by handling and anticipating their causes, governments and public agencies should confront themselves with the task to develop efficient strategies for disaster management.

A crucial aspect of such management is disaster communication, an area highly influenced by social media platforms. Citizens not only utilize platforms like Twitter or Facebook during disasters to communicate which each other, but also approach public agencies with calls for help or further information. Subsequently local officials and law-enforcement officers understand this demand and use social media to give real-time information, coordinate their responses, and get an overall impression of the situation. Research shows that instructions and information given by the government are very likely to be followed (Mileti & Sorensen, 1990), irrespective of the communication form (Liu, Fraustino, & Jin, 2016). This indicates that public authorities can incorporate all forms of communication during disasters, one of them being social media.

Previous natural disasters and the attendant use of social media by both citizens and officials can give more insight into disaster communication by means of web 2.0, a term used to refer to the use of the web as an interactive information and entertainment consummation and production platform. This research will focus on the case of Hurricane Harvey that hit the coast of Texas, on the 25th of August 2017, and caused major destruction. With a population of more than two million, the magnitude of the storm, alone in the city of Houston was immense. Disasters as such put a lot of pressure on all people involved; citizens, public officials, firefighters, doctors, etc. and pose a challenge and test to the resilience of the city against this disaster. The answer to this is the promotion of disaster resilience through stable disaster and emergency management structures and processes.

When Hurricane Harvey hit the city of Houston, its citizens and officials turned to communication via social media platforms due to several reasons. For one, many of the people affected turned to social media to send an SOS because of its big reach. The ability to simply produce messages that can be easily disseminated in different networks increases the chance of a quick rescue by official and trained field aid or volunteer helpers. Another reason for citizens to communicate their needs on social media platforms during Hurricane Harvey is the overload of emergency calls that Houston's 911 center was not able to handle. Such excessive demands were not only witnessed in the case of Hurricane Harvey but also in the

context of Hurricane Sandy in 2012 and other disasters worldwide. Twitter can support emergency management agencies in the case of overload problems of traditional information infrastructures, meaning 911 and 311 call systems, but also indirect communication through traditional media. Tweets by this replaced emergency calls and enabled agencies to become an overall operational picture very soon and comprehensive during Hurricane Sandy (Chatfield, Scholl, & Brajawidagda, 2014 - 2014). Local and national agencies such as the FEMA (Federal Emergency Management Agency) analyzed social media to get a situational impression and accordingly design their response. They also used the platforms and their reach to share information and instructions with the public (FEMA.gov, 2018; The Economist, 2017). These examples mainly refer to citizens approaching public institutions in times of need. However, these institutions need to react to that and actively and strategically use social media to prevent a uniformed and unprepared population.

Previous studies (Chatfield et al., 2014 - 2014; Murthy & Gross, 2017) on social media communication during disasters are focused on past incidents like Hurricane Sandy. There is a tendency to focus on communication between citizens rather than between citizens and public agencies. Also, most emphasis is put on the aftermath of disasters and on traditional communication channels.

This research focuses on social media communication during Hurricane Harvey from a public administration and emergency management perspective and aims to provide insights that can inform policy making for improving disaster communication. Social media is a very promising channel in disaster communication and should be integrated into disaster management strategies and policies. They enable rapid information diffusion and seeking (Liu et al., 2016), quick and broad public collaboration (Hughes & Palen, 2009) and valuable situational assessment (Luna & Pennock, 2018). Even though social media use is conspicuous during almost all recent disasters, this use seems to be rather ad hoc than strategic (The Economist, 2017). This calls for an investigation of government guidelines and processes focused on social media communication during disasters and a spot sample of their implementation in the case of Hurricane Harvey. The main research objective of this research is to develop implications and recommendations on social media use by public institutions during disasters. The following research questions will be answered to achieve this research objective through applying qualitative and quantitative research methods.

1.1. Research Questions

This thesis will answer the following main research question:

To what degree do official disaster response communication guidelines and the social media activity of public institutions during disasters take the increased need for social media communication into account?

Three sub-questions can be derived from this main research question. They will be answered with a comparison of social media data from the case of Hurricane Harvey and official guidelines found in the disaster response communication plans and guidelines of public institutions. As will be explained in the section on data sources, this study utilizes Twitter data only, representing social media as a whole.

1. *What are the differences between the stakeholder involvement in the social media communication process foreseen by the official plans and guidelines, and the stakeholder involvement visible on social media in the case of Hurricane Harvey?*
2. *What are the differences between the content of disaster messages recommended in official guidelines and the content of social media messages disseminated by public agencies during Hurricane Harvey?*
3. *What are the differences between the targets regarding continuity and accessibility of the communication process advocated in official guidelines and the quality of the communication process provided in the social media communication during Hurricane Harvey?*

By focusing on three main elements of social media communication: stakeholders, content and process, these three sub questions add interesting value to this study and help to meet the research objective. By identifying differences between government documents and the Twitter activity of public institutions in the case of a recent disaster, it is possible to evaluate the degree to which social media is sufficiently implemented in the relevant strategies and structures. The outcome of these comparative sub-questions is the identification of differences between the legal background and the reality, hinting at gaps in current policy- and decision-making.

Chapter 2: Literature Review and Key Concepts

As introduced earlier, this research focuses on social media in crisis and disaster communication in the case of Hurricane Harvey. Before the actual analysis, it is necessary to define the key concepts by reviewing the existing academic literature. The outcome of this review provides the theoretical ground for this paper. Since literature that concretely focusses on social media and disaster communication is quite limited, a lot of literature is solemnly on one of the key concepts, such as disaster communication or social media. Nevertheless, due to the rise of social media within the last view years, a rapid increase in research on social media in all spheres of science can be expected (Resnyansky, 2014).

2.1. Disaster

Houston et al. (2015) define a disaster as a traumatic event that affects the public. It can either be caused by natural power, by technology, or humanity (Houston et al., 2015; Luna & Pennock, 2018). Consequences of disastrous events can have a physical, social, psychological, sociodemographic, socioeconomic and political character (Houston et al., 2015; Luna & Pennock, 2018). Such consequences can be severe property damages, deaths, and multiple injuries (FEMA.gov, 2018). Next to this visible destruction, feelings of exposure and vulnerability weaken the affected (International Federation of Red Cross and Red Crescent Socities, 2018). An additional characteristic of disaster is introduced by the Red Cross, which describe disasters as sudden and calamitous, and seriously disrupting and disturbing the given order and functioning of a society or community. This is intensified by the inability of the community to cope my means of its own resources (Andersen & Spitzberg, 2010; Luna & Pennock, 2018).

As mentioned earlier, some disasters have a natural origin. Natural disasters “are those caused by mother earth” (Luna & Pennock, 2018). While some disasters, such as most hurricanes, can be forecasted, others can occur surprisingly (Luna & Pennock, 2018). Spence, Lachlan, and Griffin (2007) classify natural disasters as “large-scale community or geographically based events, precipitated by natural processes that severely affect society or its subunits”.

Terms that are often used in the context of, or even in exchange for “disaster”, are “risk” and “crisis”. These words are no synonyms for “disaster”, but have a different meaning. Risk describes the absence of certainty and risk communication aims to avoid crises, “catastrophic events resulting in physical, emotional or financial harm” (Sellnow, Ulmer, Seeger, & Littlefield, 2009). They are dangerous incidents that are very likely to occur due to human or natural factors (Andersen & Spitzberg, 2010). A disaster is the actual incident, which leads to a crises in its aftermath (Andersen & Spitzberg, 2010). Crises are potentially dangerous and require counteraction by public officials (2007).

Scholars active in the field of disaster research agree on the division of three main disaster phases (Houston et al., 2015): Pre-event, event and post-event. Especially the “event“ phase is interesting for the upcoming analysis.

2.2. Communication

Communication encompasses sharing and understanding: “when members or elements are in communication with one another, they are associating, cooperating, forming an organization, or sometimes an organism” (Cherry, 1994). This process of sharing ideas, thoughts and feelings occurs on the ground of mutual understanding (Hargie, 2011) and “in an effort to generate shared meanings and accomplish social goals” (Burleson, 2010). This process includes sending and receiving messages, and requires a minimum of two participants. Four interrelated actions take place in one communication process: message production, processing, interaction coordination and social perception (Burleson, 2010). Hargie (2011) identifies two central themes of communication, intersubjectivity and impact. While the first refers to the natural urge of mutual understanding, the latter describes the extent to which a message influences feelings, thoughts or behavior (Hargie, 2011).There are seven components that can be found in every process; the communicators, the message, the medium, the channel, the code, noise, and feedback (Hargie, 2011).

Communicators are the participants of the communication process, who share a “communicative relationship” (Burleson, 2010), meaning “all sorts of relationships, ranging from functional to causal to intimate” (Guerrero, Andersen, & Afifi, 2018). They can be subdivided into two groups: source and receiver, although every participant is nowadays referred to as a source-receiver, combining both characteristics in one (Hargie, 2011). Communicators simultaneously effect and are affected by each other, making the communication process transactional and a “system of reciprocal influence” (Hargie, 2011). A participant sends a message to other participants, meaning some specific content (Hargie, 2011). Content embodies “whatever it is that communicators wish to share” (Hargie, 2011). Burleson (2010) introduces two types of intentions of the communicators. For one, the intention of the source, referred to as the “expressive intention” (Burleson, 2010). The expressive intention implies the urge to express a personal, internal thought or idea to a second person, the recipient. The counterpart to this type of intention is the “interpretive intention” of the recipient, referring to the aim to understand the message (Burleson, 2010). Both kinds of intentions are influenced by social goals that require communication with others. While sources largely follow instrumental objectives when sending their messages, such as informing, requesting, and entertaining, the recipients goal is to understand the message, and its implications and requests (Burleson, 2010). Such message is always conveyed using

media and channels. The three types of media; representational, presentational and technological, differ in the level of social presence and in their ability to carry information richness. A channel "connects communicators and accommodates the medium" (Hargie, 2011). Examples for channels are sound waves or cables. Ideally, the sender is able to collect immediate feedback to his message and thereby evaluate its success and impact. "Monitoring receiver reaction enables subsequent communications to be adapted and regulated to achieve a desired effect" (Hargie, 2011).The basis of all communication is a code, meaning languages and other types of systems of meaning (Hargie, 2011). Any disruption of the communication process is referred to as noise. Noise can change content or meaning of a message and usually originates in the source, the channel, the receiver, or the context within which participants interact (Hargie, 2011).

Hargie (2011) underlines the inevitability and the purposefulness of communication. He highlights the obvious fact, that communication is always conducted with a specific goal in mind. Emphasis should also be put on the irreversibility of communication; once it's out, it cannot be revoked.

2.3. Disaster Communication

Although communication was initially no major part of disaster management, it is now accepted as a critical function in the management of disaster response and recovery (Haddow, G. & Haddow, 2014).

Communication is applied in all three management stages: planning, response and recovery (Houston et al., 2015). Or as Coombs (2010) calls them; the pre-crisis phase, the crisis response and the post-crisis phase. Communication within the first phase aims to prevent or prepare, the second one addresses a crises, and the third concerns follow-up action. Haddow, G. and Haddow (2014) add another phase. They talk of mitigation, preparedness, response and recovery. While mitigation includes the actions taken to reduce the impact of potential disasters in the future, preparedness is about the actions taken when a disaster is inevitably coming. Response refers to the immediate reactions in the aftermath of a disaster and includes actions taken to save lives, property and order. Recovery is the last phase and includes all arrangements made to get back to normality (Haddow, G. & Haddow, 2014). Accordingly. disaster communication includes both crisis and risk communication (Houston et al., 2015).

Any disaster communication strategy is influenced by some of the elements introduced by Hargie (2011), such as purpose, source, and participants, all of which will be further explained in the upcoming sections.

2.3.1. Stakeholders of Disaster Communication

Stakeholders constitute of any person or community whose lives are impacted by the disaster (Sellnow et al., 2009). The stakeholders that are involved in disaster communication are the government agencies and officials on the one hand, and the citizens on the other.

As Hargie (2011) previously stated, communicators can either function as source or receiver. Miller, David & Macintyre, Sally (2001) speak of a "circuit of communication" when it comes to the interaction between these actors. Haddow, G. and Haddow (2014) refer to the stakeholder as customers. They differentiate between internal customers, meaning staff, other federal agencies, states and other partners, and external customers, the general public, communities, economic actors, and the media. All stakeholders have their own interests and needs, and "a good communications strategy considers and reflects these requirements" (Haddow, G. & Haddow, 2014) and takes them into account when planning and designing strategies and making operational decisions.

At the first thought it seems like social and political institutions are information sources, while the citizens are mainly receivers. Official government agencies are common and trustworthy sources of disaster information. Governments refer to all levels, including the federal, state and local and government agencies, for example the National Weather Service (Houston et al., 2015). An informed public will more likely "engage in appropriate behavior" and in cooperation and collaboration (Carroll, 2013). As can be seen in research on crisis and disaster communication after 9/11, the interpersonal networks in information diffusion are very important (Spence et al., 2007). The citizens do not only simply accept the information they receive, but "make risk assessments based in sensory perception particularly in the case of natural disasters" (Spence et al., 2007). The information received by the citizens allows them to comprehend the given situation and the actions taken by fellow citizens and the public authorities (Spence et al., 2007). "Messages are often judged first and foremost not by content but by source" (Bennett, 2001). The source should ideally be informed, concerned with public welfare and responsible for the handling of the situation (Frewer, 2001).

Liu et al. (2016) find that people report strong intentions to follow instructions "regardless of information form", if given by the government. Mileti and Sorenson (1990) support this with their work on citizens reaction on public disaster communication: "publics engaging in a four-step evaluative process when they receive alter and warning messages; understanding (attaching a personal meaning to the message), believing (determining if the risk/disaster, warning and message contents are accurate), personalizing (understanding the message is aimed at the recipient), and deciding (determining

appropriate action)" (Mileti & Sorensen, 1990). Especially "believing" is relevant from a public administration perspective. In connection with the findings of Liu et al. (2016), this calls for information dispersion by public authorities due to their assumed credibility: "Public perceive official sources, such as government agencies, as more credible for disaster communication than unofficial sources, both via traditional and social media" (Andersen & Spitzberg, 2010; Wogalter, 2006). Bennett, Coles, and McDonald (2001) express the opposing view that the government is often as seen as an untrustworthy and not credible information source. More credibility and trust could be earned by competence, objectivity, fairness, consistency and goodwill. In the case of natural disasters, such as hurricanes, the threat and damage is incontestable (Spence et al., 2007). This increases the credibility of messages by the authorities and the willingness of the public to act accordingly to the government's recommendations and instructions.

Ideally, the responsible authorities combine their actions into one "Unified/centralized source of authoritative information (Andersen & Spitzberg, 2010). A central source could be established in form of a Public Information Officer (PIO) who communicates with both the affected outside and the inside of the organization (Haddow, G. & Haddow, 2014). His responsibilities include the handling of inquiries from all types of stakeholders, the articulation of warnings and rumor response and monitoring. The work of Sellnow et al. (2009) contradicts this assumption. They believe that it is helpful to engage multiple communicators responsible for particular groups. This makes the overall communication more effective and productive because "representatives of particular audiences address their own groups" (Sellnow et al., 2009), considering local circumstances.

At this point it may seem like the main players in the context of disaster communication are official institutions. Citizens appear to be simply the audience, receiving information and instructions. Such an impression is biased, since disaster communication does not only occur in a one-way fashion, and the affected populations provide data, request help and take initiative (Resnyansky, 2014). In order to make decisions about the further proceeding and the formulation of messages, the responsible authorities need to understand the situation within the community (Coombs, 2010).

2.3.2. Purposes of Disaster Communication

One of the main goals of disaster communication is to increase and maintain community resilience by connecting and reconnecting with the community (Houston et al., 2015; Resnyansky, 2014). This includes the reduction of uncertainty, and the creation of a sense of personal control over the situation (Lin, Spence, Sellnow, & Lachlan, 2016; Resnyansky, 2014). In other words, disaster communication aims to

prevent or minder the negative impact of a crisis or a disastrous event (Spence et al., 2007). This can be achieved by informing the public and recommending appropriate behavior (Carroll, 2013; Shenhar, 2014). Stakeholders need to be informed about the circumstances because every disaster or crisis implicates a "knowledge vacuum" (Coombs, 2010). This especially applies in the response phase, where the provision of precise and correct information is the main communication purpose (Haddow, G. & Haddow, 2014).

Renn (2010) identifies four major functions of risk communication: dealing with the public perception, changing the individual behavior, gaining trust and credibility, and involving stakeholders in the communication process. While the main aim is to protect the stakeholders, secondary goals such as protecting reputational and financial assets play additional substantial roles (Coombs, 2010). The reputation of an organization can even be improved, since an often intended side-effect is to establish public confidence in the capability of an organization (Carroll, 2013).

The effectiveness of disaster communication may influence the impact of the disaster in a positive and negative manner (Houston et al., 2015). Its development and improvement should therefore be highly prioritized by all stakeholders involved.

2.3.3. Content of Disaster Communication Messages

Information should be provided in a timely and accurate fashion in all phases of disaster management (Haddow, G. & Haddow, 2014; Hallahan, 2010). In the mitigation phase, the implementation of strategies, technologies, and actions are communicated. Preparedness messages educate and inform the public right before the disaster event. Warnings, evacuation appeal and reports on the current situation are part of the response communication, while messages distributed during the recovery phase mainly focus on the registration and receiving of disaster relief (Haddow, G. & Haddow, 2014).

As mentioned before, the most common intention is the simple provision of information. The affected individuals need information about what has happened and what is happening in the disaster-affected area (Kim, J., Bae, & Hastak, 2018; Spence et al., 2007). "All people exposed to risks should have sufficient information to cope with risk situations" (Renn, 2010). Next to informing the public, disaster response communication activities also include "warning, mobilizing, and instructing the population" (Resnyansky, 2014). Additionally, the citizens are being informed about the decisions made and actions taken by the government (Renn, 2010).

Andersen and Spitzberg (2010) find that "slowly unfolding disasters demand more media consumption and confirmation than sudden disasters" and that with increased complexity of a disaster, the media

messages encounter larger acceptance by the public. Effective disaster communication must include visual or auditory means of presentation to catch more attention and raise greater awareness (Sellnow et al., 2009).

In order to comprehend the situation and disseminate correct information, data on the incident and its consequences must be collected and analyzed (Haddow, G. & Haddow, 2014). The importance of this is shown by Frewer (2001) who finds that the effectiveness of risk communication is increased if the messages focus on the "actual concerns of the public regarding a particular hazard, not just those concerns which are believed to be important by experts". The following information diffusion refers to a "process by which ideas, relevant information, technical practices and commercial products spread throughout a social system" (Neuwirth, 2010).

2.3.4. Challenges in disaster communication

As in most issues concerning the general public, inequality can be a challenge in the context of disaster communication. According to Spence et al. (2007) people with low income and the unemployed have disadvantages when it comes to crisis and disaster preparedness. These occur most in the process of information seeking, referring to differences in accessibility of disaster related information.

Knobloch-Westerwick and Taylor (2008) examine disaster communication from a slightly different perspective and introduce the term "blame game". They describe it as "news about actors in the public arena as they try to deflect, deflate or diffuse blame for negative events so that the public does not view them as the cause of harm" (Knobloch-Westerwick & Taylor, 2008). This phenomenon is closely related to the issue of credibility, as introduced earlier. Agents that seem to have some connection to the negative event, try to obscure their own responsibility. Their findings show that the use of an active voice to describe the actions taken in the context of negative event, leads to more blaming, than after the use of a passive voice. Additionally, their research shows that "facets of causal attribution – perceived control and intention – affect perceptions of agents traits, as well as assent and support for the changes targeted by the news agents" (Knobloch-Westerwick & Taylor, 2008).

Communication plays a very important role in the context of blame. Knobloch-Westerwick and Taylor (2008) refer to experiments that even small changes in the simple description of events can change the public's perception of the event itself and responsibilities and accusations. Bainbridge and Galloway (2010) emphasize the power of media, who lead and cause discourses on blame.

2.4. Social Media

Types of mass media are television, radio or social media (Liu et al., 2016). Disaster warnings for example, are typically expressed by government agencies and are then disseminated through mass broadcast channels (Houston et al., 2015). Traditionally, mass media provide the platform for communication at any stage of the disaster, since they are the dominant communication channel (Spence et al., 2007).

Peterson and Thompson (2010) dig deeper into the realm of mass media. They criticize the American media landscape, by naming the New York Times as one of the only mass media providing reliable and sophisticated information "to take someone much beyond simple awareness of the issue" (Peterson & Thompson, 2010). Emergency managers should always commit themselves to a partnership with the local media outlets. Haddow, G. and Haddow (2014) understand that local news are the best news during a disastrous event, "people will track down local information on whatever platform they can find it".

Recently in America, the internet and therefore social media is "the most important source of information for people under the age of 30", while older American citizens rank it second after television (Alexander, 2014). Social media have become a primary communication channel (Luna & Pennock, 2018).

The term social media refers to internet-based platforms and services such as blogs, micro-blogs, social bookmarking, forums, collaborative creation of documents and the sharing of audio, photographic and video files (Alexander, 2014; Houston et al., 2015). People can generate, share and consume content simultaneously and almost in real time in virtual communities (Nepal, Paris, & Georgakopoulos, 2015), they become the hybrid form source-receiver. It is often used interchangeably with "web 2.0" or "social networking" (Houston et al., 2015).

One characteristic of social media is interactive communication, meaning the two-way, synchronous exchange of message content (Alexander, 2014; Houston et al., 2015; Williams, Valero, & Kim, 2018). Social media platforms allow users to establish public or semi-public profiles and content and connect and collaborate with other users, both individuals and organizations (Houston et al., 2015). They can be accessed by different computing devices, enabling both traditional media content creators and users to create and consume content (Houston et al., 2015; Nepal et al., 2015).

Social networks constitute one specific type of social media. They are the most popular social media tools and allow users to construct a profile within a bounded system, articulate a list of individuals with whom they share content and view and traverse their list of connections and those made by others

within the system (Nepal et al., 2015). Examples are Facebook, Google and Twitter. Such networks can be based on friendship, interest, circumstances of professional career.

The interaction between the different stakeholders on social media forms “connections that emerge into complex social network structures” (Himelboim, Smith, Rainie, Shneiderman, & Espina, 2017). Such connections develop when user share content and mention other accounts. The network structures arising from these connections can implicate different types of information flow: “networks in which people are very highly interconnected are better at transmitting information” (Burt, 2007). The work of Himelboim et al. (2017) develops a framework to classify Twitter conversations based on the patterns of information flow. For example, “users can use social spaces to recreate and reinforce traditional hierarchal structures by continuing to rely on just a few information sources or by choosing to limit interactions to a select group of similar other” (Himelboim et al., 2017).

Social media are not solemnly used in the private sector, but also by governments at all levels for a variety of purposes, mainly to “connect with those they serve” (Bertot, Jaeger, & Hansen, 2012). One can observe a major trend of social media utilization in government agencies (Criado, Sandoval-Almazan, & Gil-Garcia, 2013; Graham, Avery, & Park, 2015). Examples for the use of social media by governments are the provision of accurate information to citizens, the participation of citizens in policy formulation, and the improvement of internal communications (Nepal et al., 2015), all of which can be captured with the umbrella term “e-government” (Bertot et al., 2012; Criado et al., 2013). Social media can enable improvement in decision-making and problem-solving (Bertot et al., 2012). The process of social media adoption by the government is, like any other structural and organizational transformation in this sector, proceeding slower than in the private sector. This process does not necessarily happen simultaneously in all government agencies. Citizens expect the governments activity and availability on social media (Bertot et al., 2012), posing an inevitable need for social media in all administration areas. The most popular social media platform from a government perspective is Twitter, followed by YouTube and Facebook (Nepal et al., 2015). Although social media become more and more relevant in the government sector, Nepal et al. (2015) find that there is room and necessity for further increase in the use.

2.5. Influence of Social Media Use on Disaster Management and Communication

2.5.1. Positive Influence: Benefits and opportunities

On the one hand, social media provides great chances for disaster communication. The use of the internet has increased the “need for speed”, meaning real-time updates, within the community (Coombs, 2010; Hallahan, 2010; Luna & Pennock, 2018; Williams et al., 2018). Social media enables the

broad public to collaborate during a crisis or disaster through a “rapid mass self-communication” (Hughes & Palen, 2009; van der Meer & Verhoeven, 2013).

It is therefore inevitable to integrate the internet and its platforms into every disaster response strategy. Liu et al. (2016) identify particularly Twitter as a promising tool because of the speed and reach the text-based tweets have. The most important aspect is that tweets can be shared without limitations, such as friendship-status. “Twitter provides opportunities for rapid crisis communication in response to the escalating character of crises and for frame negotiation and alignment” (van der Meer & Verhoeven, 2013).

Liu et al. (2016) apply the ICTs succession theory on social media use during disasters. The main thoughts of this theory are that “using two different information forms such as one that primarily relies on visuals and the other that primarily relies on text to repeat a message can be more persuasive than only using one information form” and that “people are more likely to understand the urgency of an emergency when they received information via three messages.” (Liu et al., 2016). For instance, Twitter enables users to repost and further distribute information. This repetition in connection to combining text-based posts and tweets with pictures and videos supports the advantage of social media use during disasters.

“The internet has proven to be a powerful tool to organize disaster relief efforts”, as can be seen when looking at previous disasters (Hallahan, 2010). Studies on disaster communication show that people have understood the chances of social media as part of disaster communication and their critical role, especially regarding the diffusion of emergency information (Kim, J. et al., 2018). Kim et al. (2018) proof that this was the case during Hurricane Cindy in the U.S. The fact that almost every governmental agency has social media accounts that can be, and are used as emergency communication channels supports this understanding and shows that public agencies are aware of “the unique characteristics of social media and networks for better emergency communication systems” (Kim, J. et al., 2018). This hints at the main use of social media, the communication of emergency information and urgent requests between emergency agencies and disaster-affected communities.

Williams et al. (2018) support the claim of increased social media use by public institutions. They witness that organizations create social media pages and build their own social media network to address the general public. Also Nepal et al. (2015) observe that government agencies use social media to build disaster resilient communities through shared responsibility. Social media offers means for data collection, information dissemination and coordination or response and recovery attempts.

Examples of agencies using social media are local departments of emergency management, state departments of public safety, the US Federal Emergency Management Agency and the NWS (Houston et al., 2015). In their research, Graham et al. (2015) lay focus on social media use in local governments during a crisis. They emphasize that social media use is no privilege of the national government and its agencies, but that especially during a disaster, the local component plays a significant role (Graham et al., 2015). This can be helpful in the context of disaster management since the range of one single post or tweet can be significantly increased by sharing and retweeting within different social media networks. They also claim that more trust in local emergency management agencies, leads to an increased use of social media during a disaster, specifically an "increased willingness to turn to official social media sources" (Williams et al., 2018).

Examples for social media use for the communication between public agencies and citizens can also be found outside the United States. The case study on Thailand's flooding disaster from 2011 by Kaewkitipong et. al. (2012) lays emphasis on the essential role of social media during disasters. Kaewkitipong et. al. (2012) use the intensive study of Thailand's floods to identify the main intentions of social media use during disasters: information sharing, forming of groups for different crisis management needs, collaboration of government agencies with online communities, the production of accurate and up-to-date information that can be retrieved from a central location and reporting live statuses with the help of geographical locations.

Several scholars emphasize the benefits of social media when it comes to gaining a comprehension of the situation via data collection (Luna & Pennock, 2018). Luna and Pennock (2018) summarize the requirements for such data collection. The data should "provide a significant description of the situation", "allow understanding the relationships among components", "provide enough information to facilitate development of potential future states" and "be able to facilitate the decision-making process". Social media content can give an impression of the circumstances around an event within society "that allow for interpreting situations, making decisions and predicting future outcomes" (Luna & Pennock, 2018).

Alexander (2014) identifies seven different kinds of social media use in case of an emergency: "listening to public debate, monitoring situations, extending emergency response and management, crowd-sourcing and collaborative development, creating social cohesion, furthering causes and enhancing research".

Social media are beneficial in the sense that they can help to overcome geographical distances (Wiederhold, 2013) between people and that they can simplify information seeking, which can eventually lead to the creation of publics via online collaboration (Hallahan, 2010). From an organization perspective, social media use is advisable because of it is "low-cost, easy-to-use, scalable, mobile, reliable and fast network that provides capacity for one-to-many communication, includes information and has geographic information systems capacity and visualization tools" (Houston et al., 2015).

Social media as part of disaster management promises "increased information capacity, dependability, and interactivity" (Houston et al., 2015). It is therefore not surprising that one can observe an increasing integration of social media into existing disaster systems by the government. Social media "has the potential to save tens of thousands of lives per event and to help target assistance to the most needy survivors of a natural disaster" (Wiederhold, 2013). Nevertheless, the integration and verification of information presents a major challenge across jurisdictions and communities, and particularly, with regard to jurisdictional borders (Chatfield et al., 2014 - 2014). The full potential of social media use during disasters is not yet effectively integrated in official strategies and policies.

Table 1 Benefits and Opportunities of Social Media in Disaster Communication – Summary of the Literature Review

Benefits and Opportunities of Social Media	References
Real-time update, rapid information diffusion	Coombs (2010), Hallahan (2010), Luna and Pennock (2018), Kim, J. et al. (2018), Kaewkitipong, Chen, and Ractham (2012), Liu et al. (2016)
Easier and faster collaboration of the broad public	Hughes and Palen (2009), van der Meer and Verhoeven (2013), Kaewkitipong et al. (2012), Alexander (2014)
Big reach – reaches the masses	Hughes and Palen (2009), van der Meer and Verhoeven (2013), Kaewkitipong et al. (2012), Alexander (2014), Liu et al. (2016)
Stronger support for organizations	Liu et al. (2016), Williams et al. (2018)
Repetition and diffusion of messages	Liu et al. (2016), Houston et al. (2015), Kim, J. et al. (2018)
Interaction between government and citizens	Williams et al. (2018), Kim, J. et al. (2018), Kaewkitipong et al. (2012)
Shared responsibility, increased level of social cohesion	Nepal et al. (2015), Alexander (2014), Hallahan (2010)
Identification of geographical location -> reporting live statuses	Kaewkitipong et al. (2012), Houston et al. (2015)
Situational awareness via Data Collection and Feedback	Luna and Pennock (2018), Alexander (2014)
Low cost	Houston et al. (2015)
Mobility	Houston et al. (2015), Wiederhold (2013)

2.5.2. Negative Influence: Risks and challenges

Although social media has become invaluable in all spheres of communication, its limitations cannot be ignored. For example, Twitter, Facebook and other platforms are useless, when batteries run out or the IT infrastructure fails (Haddow, G. & Haddow, 2014).

One relatively influential problem with social media is its negative correlation with age and positive correlation with educational achievement (Alexander, 2014). Nevertheless there is a trend to increase use of social media in all age and income groups. Luna and Pennock (2018) refer to the FEMAs Strategic Foresight Initiative which identifies key challenges that might affect emergency management activities. These include the increase in US population and in elderly population, an increase in ethnic diversity, the developments of megaregions, and an increase in coastal population density and shifts in demography. These social challenges are accompanied by technical challenges such as limitations in governing physical and logistical resource to support the functioning of social media applications, the issue of data ownership, the issue of how long records are kept and who manage the applications, system security, data security, social media monetization, the possible ignorance of critical government messages (Luna & Pennock, 2018).

On the other hand, the effectiveness of social media can be questioned when comparing it to traditional forms of media. According to the media-richness theory, rich forms of communication should be used in times of uncertainty and ambiguity, meaning the use of visual and social cues (Liu et al., 2016). This rather supports the use of traditional media, especially television and radio, because they can to provide these visual and social cues. Social media is often text-based, in which case visual cues are not provided. However, if pictures and videos are part of tweets and posts, this visual component is given. Social media implementation may cause organizational changes “related to the range of participating actors and their roles; the hierarchy of needs and goals; and the issues that require attention” and can lead to the inclusion of new and more stakeholders (Resnyansky, 2014).This can lead to uncertainty about their roles during all phases of the disaster, their authority and legitimacy, and their responsibilities (Resnyansky, 2014).

A big threat to the credibility of social media messages are rumor propagation and the distribution of false information (Alexander, 2014). Both can lead to an increase of chaos in insecurity in the context of uncertain events (Alexander, 2014). Correct and important information may disappear in the huge amount of posts and tweets “a high volume of messages via social media makes it hard for disaster-affected communities and emergency responders to analyze the information” (Kim, J. et al., 2018).

Facing the problem of rumors, the Federal Emergency Agency opened a new rumor control page to debunk false rumors related to Hurricanes Harvey and Irma (Kim, J. et al., 2018) .

New media technologies become an origin of crisis (Hallahan, 2010). A new form of noise in the communication process as defined by Hargie (2011) occurs through social media, namely bots and trolls. Bots is an acronym for robot, and refers to an internet-based algorithm that "performs highly repetitive tasks by automatically gathering or posting information" (Michael, 2017). Harm is done once they manipulate situation by providing wrong or irrelevant information: "they can target individuals or groups and successfully alter or even disrupt group-think, and equally silence activists trying to bring attention to a given cause" (Michael, 2017).

Next to this algorithm-based threat which requires advanced programming knowledge, social media also enables people to undermine social network operations with their personal accounts. This is referred to as trolling: "Trolling is an inclusive term that characterizes different types of disruptive online behavior ranging from off-topic joking comments to offensive and threatening behavior. Different from spammers, troll do not aim at a financial gain; creating disarray is a goal. Typical examples of trolling behavior include mocking and discrediting discussion participants, inciting and escalating arguments, and impersonating expert users while spreading bad advice and false information" (Tsantarliotis, Pitoura, & Tsaparas, 2017). Challenges of social media identified by Bertot et al. (2012) are privacy, security, data management, and accessibility.

Table 2 Risk and Challenges of Social Media in Disaster Communication – Summary of the Literature Review

Risks and Challenges of Social Media	References
Dependency on battery and infrastructure	Haddow, G. and Haddow (2014), Luna and Pennock (2018), Bertot et al. (2012)
Negative Correlation of social media use and age	Luna and Pennock (2018), Alexander (2014), Bertot et al. (2012)
Positive correlation of social media and educational achievement	Alexander (2014), Bertot et al. (2012)
Question of data ownership	Luna and Pennock (2018), Bertot et al. (2012)
Data security	Luna and Pennock (2018), Bertot et al. (2012)
Social Media monetization	Luna and Pennock (2018)
Ignorance of government messages	Luna and Pennock (2018)
No/rare visual and social cues	Liu et al. (2016)
Cause of organizational changes (hierarchy, responsibility etc.)	Resnyansky (2014)
Involvement of too many stakeholders	Resnyansky (2014)
Rumor propagation	Kim, J. et al. (2018), Alexander (2014)
Bots and trolls	Michael (2017), Hallahan (2010), Tsantarliotis et al. (2017)

2.6. Conceptual Model

The extensive literature review eventually leads to the development of a conceptual model, as shown in Figure 1. This model merges the findings and theories on communication in general, with those on disaster communication and social media. It will function as a basis and structure for the upcoming analysis and visualizes the main hypotheses.

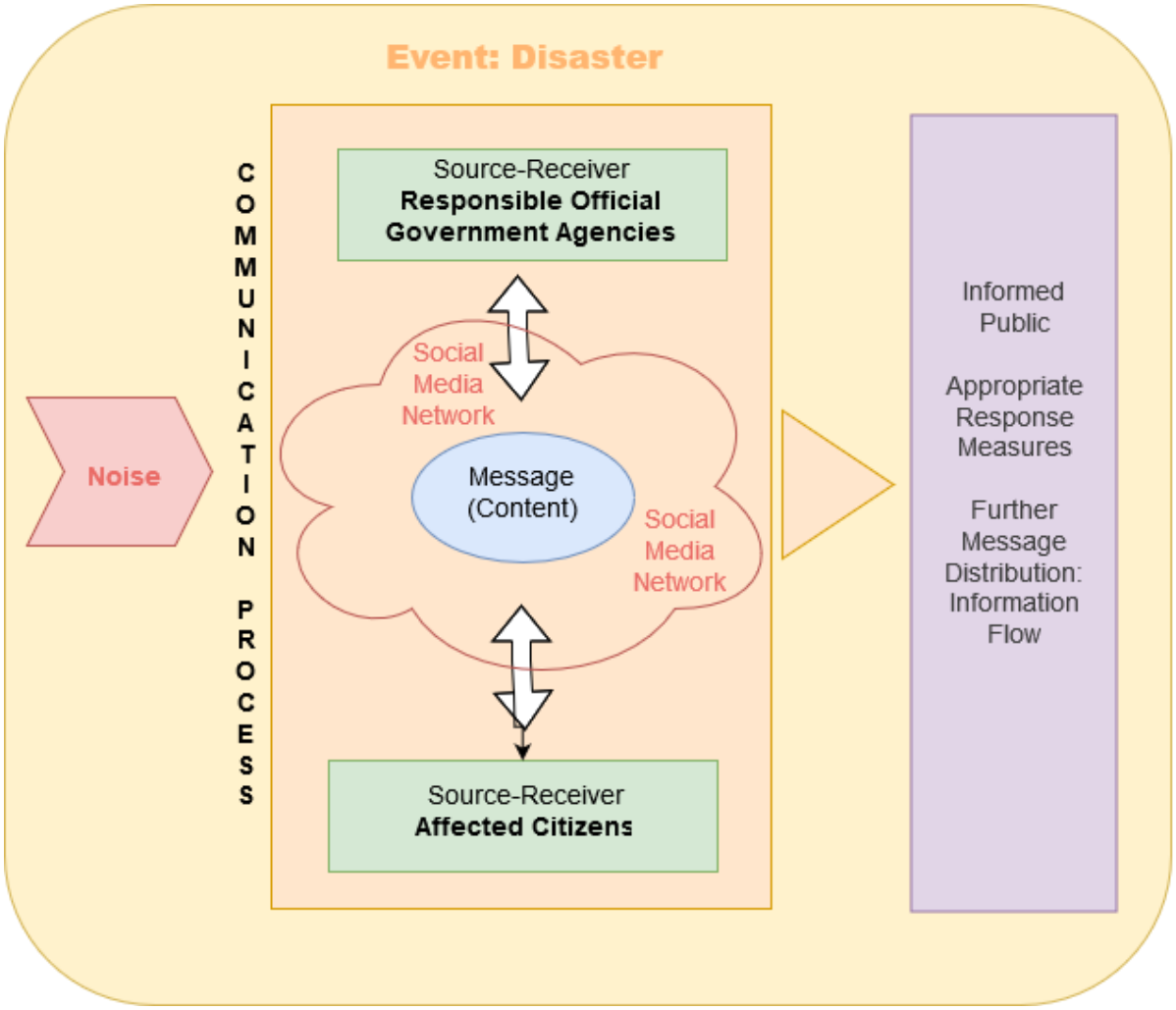


Figure 1 Conceptual Model derived from the Literature Review

All four sub-questions, which were formulated in Chapter 1, aim at an analysis framed by this conceptual model. The analysis will be structured with the different elements of this conceptual model: process, actors, content, and outcome. All of these elements have been identified by Hargie (2011) and have been applied to literature and theory on disaster communication and social media.

Chapter 3: Methods

3.1. Research Design

This research is based on a mixed-methods single-case study research design and consists of an in-depth comparative review of social media use in disaster communication. Specifically, requirements and guidelines of government documents are compared to Twitter data. Basis of this research is the conceptual model developed in the previous chapter. The overall outcome is a comparison of the official guidelines and goals on disaster communication via social media with the actual social media activity during Hurricane Harvey, aiming to achieve the research objective by making recommendations for effective disaster communication strategies.

The dates of analysis are the 25th of August 2017 till the 28th of August 2017. During this period Hurricane Harvey lingered over Houston and its surroundings and can therefore be classified as the response phase in disaster management. Response phase refers to the immediate reactions in the aftermath of a disaster (Haddow, G. & Haddow, 2014). Citizens, public institutions and other stakeholders are the focus of this research, specifically their Twitter accounts and appearance. Basis of the analysis are all tweets using the keyword H*urricane Harvey* in this time.

Potential threats to this research design are mainly related to data collection from social media. By focusing on Twitter only, other social media platforms are left out. Nevertheless, this focus is justified, since Twitter is the platform used most frequently and extensively during Hurricane Harvey (The Economist, 2017). Similar threats can be identified in connection to the categorization of tweets since there can be room for false labeling of the tweets and accounts, which are further explained in the operationalization of each sub question. However, this is prevented to the largest extent possible by double checking all accounts and tweets labelled. Another potential threat is the time frame, laying a focus on Houston's metropolitan area. Hurricane Harvey also affected other areas in the U.S. This entity will remain since an urban policy perspective was chosen which is easier applicable to a defined and specific urban area. Moreover, social media is one of various channels used in the realm of disaster communication. It affected by "offline" factors, which is not sufficiently taken into account within this research due to its scope.

3.2. Case selection

My research consists of a single case study on Hurricane Harvey, which enables an in-depth analysis. As mentioned before, Hurricane Harvey hit the United States at the end of August 2017 and thereby is the

most severe recent hurricane affecting America. According to Walters (2018) it is the second costliest cyclone in US history. Hurricane Harvey originated in a tropical wave that emerged from the African west coast in the 13th of August (Commerce, NOAA, & Service). By the 25th of August Harvey had reached the 4th hurricane category, referring to 130mph winds. Its eye made landfall on San Jose Island, Rockport and Fulton and hit Houston the same day. Instead of leaving the coast and moving inland, Hurricane Harvey lingered over Houston and caused severe damages until the 29th of August (Commerce et al.). Case-related data from social media accounts of individuals and agencies is used to enable this case study. Their selection is therefore mainly based on the characteristic of using social media networks during Hurricane Harvey. Since this research investigates the use of social media during disasters, this selection is reasonable.

It is very relevant in the context of this research that Hurricane Harvey is referred to as the "U.S.´s first social media storm" (Rhodan, 2017). This, together with its topicality and the fact that there is very little reflection on disaster communication during this hurricane, are the main reasons for the selection of this case. This research is also part of a collaboration project between the University of Twente and the Stevens Institute of Technology on urban resilience. A city's resilience is regularly challenged by various shocks and stresses. Examples for such shocks can be men-made or natural disasters. Therefore, research on natural disasters, such as Hurricane Harvey is very relevant in the context of this project.

3.3. Data sources and data collection

Overall, this research is structured as a comparative analysis of data that are collected from two sources, namely official documents and Twitter. The following selection describes the sources and the data.

3.3.1. Official documents

Bertot et al. (2012) observe that the rapidness of social media adoption by both the citizens and the government agencies outruns the legal framework. Nevertheless, some leading principles and rules are highly relevant and influential in the context of social media use, such as the Paper Reduction Act, the E-government Act and the Information Quality Act (Bertot et al., 2012). These acts are not further analyzed, but provide the basis for most of the investigated documents. They include the following key principles and messages. Agencies have to inform the public efficiently, equitably, fast and with the minimum consumption of paper resources (Paperwork Reduction Act, 1995). They are also required to use Internet-based information technology to enable public access to government information and services (E-government Act, 2002), and to ensure that the information is objective and applicable (Data Quality Act, 2011). The documents used in this thesis were selected in several steps "reading a small

sample", "examining headlines or abstracts for clues to relevance of texts" (Krippendorff, 2009). This selection is based on the assumption, that all relevant documents are made publicly available on the internet, according to the Open Government Plan, ensuring transparency, participation and collaboration (Open Government Plan, 2016).

Relevant documents were identified by using the keywords *emergency communication, disaster communication, crisis communication, disaster response, United States*, and *Houston* in the official data search engine of the U.S. government (www.data.gov). The following documents were identified:

Table 3 Relevant Government Documents on Disaster Communication

Document	Type	Source
National Response Framework	Framework	Department of Homeland Security
Texas Emergency Management Executive Guide	Guide	Texas Department of Public Safety Texas Division of Emergency Management
FEMA – Publication 1	Doctrine	FEMA
Local Mitigation and Planning Handbook	Guide	FEMA
National Incident Management System	Framework	Department of Homeland Security
Response Federal Interagency Operational Plan	Plan	Department of Homeland Security

3.3.2. Twitter Data

To get an impression of the social media communication during Hurricane Harvey, a random sample of Twitter data was collected by running a code in Python, looking for the keyword "Hurricane Harvey" in the time frame from 25th of August till the 28th of August 2017. This was enabled through the public Twitter API. All tweets are processed and cleaned using Python. The resulting dataset consists of 415.498 tweets, out of which 83.758 include mentions. This will be further explained in the upcoming sections. Twitter has become an attractive data source in the context of humanitarian assistance and disaster relief (Vivek Wisdom & Rajat Gupta, 2016). Benefits of such data are its quantity and the diversity of information that can be derived from it. Twitter data includes information on the account, the content of the tweets, geolocations if available, the language used, the date and time of tweet creation and mentions, among others. This is no surprise since people use the microblogging website to post their opinion, discuss issues, complain to companies and public institutions and express their sentiments (Vivek Wisdom & Rajat Gupta, 2016).

3.4. Data Analysis

This research uses both quantitative and qualitative data to answer the research questions. The government documents are systematically analyzed, inspired by the methods applied in the work of Kapucu, Haupt, and Yuksel (2018). Precisely, a text-driven content analyses, as defined by Krippendorff (2009) was conducted by reviewing documents covering the topics disaster communication and social media. Foregoing the analysis answering the three sub questions, is a count of social media related terms in all investigated government documents. Besides the content of the document, type and source are also relevant. The sources mainly differ regarding their jurisdictional level, meaning federal, state or local governments and institutions. Most documents come from national sources, such as the Department of Homeland Security, the US Environmental Protection Agency, the Department of the Interior, the US Department of Commerce, the National Oceanic and Atmospheric Administration, and the US President. State sources in the context are the Texas Department of Public Safety, and the Texas Division of Emergency Management. The type of the document gives information on its binding force. An act of the legislature is a binding law of the United States (U.S. Senate Website, 2017), while a doctrine is a principle of government policy. A framework on the other hand is a collection of guiding principles which are considered as soft law and is therefore not strictly binding (Legal & Inc, 2018). The same applies to guides, plans, and reports. They are not directly enforceable (Legal & Inc, 2018), but nevertheless useful tools to guide decision-making in the context of disaster management. From this point on the relevant government documents will be referred to with the following acronyms: National Response Framework (NRF), Response Federal Interagency Operational Plan (RFIOP), National Incident Management System (NIMS), Texas Emergency Management Executive Guide (TEMEG).

Twitter-Data-Analysis enabled by Python constitutes the second part of this research. Social networks like Twitter provide great opportunities for an “efficient analysis of massive real-time data” (Vivek Wisdom & Rajat Gupta, 2016). Their analysis can give insight on conversation topics, characteristics of individuals or organizations tweets, and opinions (Kim, A. E. et al., 2013). Such meaning can be derived from the Twitter data through “Natural Language Processing”, a method to mine large volumes of text based data for patterns and meaning (Kim, A. E. et al., 2013). The analysis is based on Twitter accounts and tweets, enabling a stakeholder analysis, social network analysis (SNA), and content-analysis. All results are visualized with the help of the visualization tool “Gephi” ("Gephi - The Open Graph Viz Platform," 2017).

3.4.1. Analysis of the data to answer sub-question 1

What are the differences between the stakeholder involvement in the social media process foreseen by the official plans and guidelines, and the stakeholder involvement visible on social media in the case of Hurricane Harvey?

Sub question 1 is answered with the help of a stakeholder analysis. As a first step, the selected government documents are screened for content on actors, stakeholders, responsibilities, authorities, communication and social media activity. This view of documents takes the finding of Kapucu et al. (2017) that there is no official precise solution stated, but that these documents "are guiding tools explaining roles, responsibilities, and recommendations on how to apply resources of national preparedness" into consideration. As a result, information on types of stakeholders and the responsibilities of public institutions in the communication process is extracted. Specifically, categories for the ensuing analysis of the Twitter data are derived: types of stakeholders, and the jurisdictional levels. This categorization, guided by the findings of scholars like Haddow, G. and Haddow (2014), is applied to the social media data.

All Twitter users active within the four days of the hurricane using *Hurricane Harvey* in their tweets are labeled as one of the stakeholder types. This enables a categorization of all actors involved. For better comprehension of this approach, it is necessary to explain what *involved actors* implies. Active accounts are referred to as *Actors,* regardless if they represent one individual, a group, an agency, or any other political or social institution. To ensure lucidity, only accounts with 10 or more tweets during the disaster are taken into consideration. Ground for the labeling is found in their name and the description in their bio. For example, accounts that have "Gov" included in their Twitter ID are categorized as public agencies. Also, only "verified accounts" are taken into account when it comes to the stakeholder groups *Public Institutions* and *Media.* According to the official Twitter website, verified accounts are "determined to be an account of public interest. Typically this includes accounts maintained by users in music, acting, fashion, government, politics, religion, journalism, media, sports, business, and other key interest areas" (Twitter.Inc, 2018). This is not as relevant for accounts labeled with *citizens, private sector* or *non-governmental organizations*, since they do not necessarily fall under the scope of public interest. Table 4 summarizes the words and letters that indicate either one of the stakeholder groups.

Table 4: Code for Stakeholder Categorization

Stakeholder Group	Indicators in Names	Indicators in Bio
Public Institution	"Gov", "Sen", "Senator", "cityof", "sheriff", "police"	Link to official government website Indication of verification through Twitter
Media	"Fox", "News", "CNN", "tribune", "Magazine", "Mag", "TV", "channel", "media", "MSNBC"," CNBC"	Link to official media website Indication of verification through Twitter
Non- Governmental Organizations	"charity" "NGO"	Link to media website Indication of its purpose
Private Sector	"inc", "company"	Link to official company website Indication of business purpose
Citizens	Nicknames, numbers in the names, "mom", "dad", "citizen"	Description of their personal life Personal information

As a next step, the share of each stakeholder group is calculated by dividing the number of accounts categorized in each group through the number of all active accounts in the data set. This calculation provides indication on who is active on social media during the disaster. The same categorization method is applied to the accounts mentioned in the tweets. A Twitter mention is introduced with an "@" and specifically addresses the person following this sign. This categorization process is included in the operationalization model as one key step in the operationalization of the first sub question answered with a stakeholder analysis (Figure 3). After labeling these accounts applying the same code and calculating the share of each mentioned stakeholder group, the results on the active and mentioned accounts are compared to identify discrepancies or similarities. The active accounts represent the stakeholders taking initiative during the disaster, actively participating in the communication process and distributing messages. The mentioned accounts are passively included in the communication process and represent who the social media users require or desire to join the communication process. The comparison of these values is then related to the results of the previous document analysis to identify intersections between official requirements and the reality on social media.

A similar approach was chosen to further investigate the social media activity of public institutions. As mentioned at the beginning of this section, the relevant jurisdictional levels are extracted from the government documents. These are used to label Twitter accounts of public institutions. To ensure clear results, only the top 26 accounts labeled with *Public Institution* are taken into consideration at this point. Again, the same labels are applied to all mentioned accounts labelled with *Public Institution.* The categorization is carried out by opening the official links provided in the bios, referring to the public institution and its jurisdictional level. Again, the shares of each jurisdictional level are calculated for both

active and mentioned accounts, enabling a comparison and the establishment of relations to the results of the document analysis. The analysis is concluded with an overall comparison of all results.

3.4.2. Analysis of the data to answer sub-question 2

What are the differences between the content of disaster messages recommended in official guidelines, and the content of social media messages disseminated by public agencies during Hurricane Harvey?

The investigation of sub question 2 follows a very similar schema as the previous one and builds on results of the precedent analysis that there was involvement of public institutions on social media, as predicted by Kim, J. et al. (2018). First, the government documents are analyzed by identifying content on public education, public outreach, messages, message content, social media, and tweets. This content analysis results in the extraction of the most emphasized topics that should be distributed in the official messages in the disaster communication process. Haddow, G. and Haddow (2014) and Resnyansky (2014) give a first impression of what these topics may look like. Additionally, relevant required characteristics of such messages published by the responsible institutions are summarized. This summary is guided by the literature. Both, the characteristics and the main topics, are applied in the analysis of the social media data as a next step.

Again, the Twitter data is labeled, using the results of the document analysis. This time the focus is on the tweets posted by the most active public institutions between 25th of August and 28th of August, 2017. The categorization is done by reading all tweets, investigating the syntax and the intended implications of these messages. Moreover, the results are prepared for interpretation by calculating the shares of each topic in the investigated tweets. As a next step, this is related to the findings of the document analysis, reviewing the actual Twitter activity of the public agencies for compatibility with the official guidelines. Additionally, the coordination, as emphasized by Andersen and Spitzberg (2010), in the context of disaster communication on social media is checked by screening the tweets for identical messages. This is done using computational methods, looking for word repetitions and composes the third step within the content analysis, as shown in Figure 3.

3.4.3. Analysis of the data to answer sub-question 3

What are the differences between the targets regarding continuity and accessibility of the communication process advocated in official guidelines and the quality of the communication process provided in the social media communication during Hurricane Harvey?

Since this research is structured as a comparison between government documents and twitter data, the investigation of the third sub-question begins with a content analysis of the previously identified documents, extracting content steps to be taken by the affected agencies and officials during the response phase, and on the information flow and distribution process. Results of this analysis include targets, procedures and principles on disaster communication and social media. Their compliance in the case of Hurricane Harvey are tested in two steps using the Twitter data.

First, the tweets by the most active public institutions that have been labeled as part of the previous sub question are further investigated by adding the time component. Precisely, the development or trend of each topic is the focus of this analysis. This can give insights into the priorities set by the public institutions at the different stages of the disaster, its procedural compliance and its influence on the quality of the communication process.

The second part of the social media analysis is the conduction of a Social Network Analysis (SNA) of the Twitter users. As mentioned in the literature review, comprehending the structure of a network is a key step to understand the information flow between users (Himelboim et al., 2017), which is why the network analysis constitutes a major part within the process analysis answering sub question 3 (Figure 3). Social networks for each day are visualized using Gephi ("Gephi - The Open Graph Viz Platform," 2017). To make the graphs clearer and easier to understand, two data filters are applied: “giant component” and a filter on the degree values below 2. Degree in this context refers to the number of connections a node has. The Giant component filter generates a visualization of the main “connected component that contains a significant fraction of all the nodes” and “excludes components that are not connected to the main component” (Easley & Kleinberg, 2010). A social network consists of nodes and edges. Nodes are visualized as circles and represent the sources and targets of messages, meaning the Twitter accounts. Edges, on the other hand, visualize the connection between these nodes with a line. In this case each connection is a mention. The size of the nodes is dependent on their betweenness centrality, which measures the centrality in a graph by indicating the shortest paths between nodes (Kiesling, Klünder, Fischer, Schneider, & Fischbach, 2016). The nodes are colored and partitioned according to their modularity class. Modularity represents community structures (Gianetto & Heydari, 2015), which leads to similar coloration of nodes that belong to the same community. Four network level metrics define this structure and enable a network analysis when investigated together, besides modularity, these are density, centralization, and isolates.

Himelboim et al. (2017) developed a conceptual and practical model for the classification of Twitter networks based on their network-level structures. They identify six types of such structures: Inward hub-and-spoke, outward hub-and-spoke, divided, unified, clustered and fragmented. This model is the basis of the SNA and is summarized in Figure 2. Clusters refer to subgroups of interconnected individuals. The extent of connectivity across these groups determines information flow across different social groups since they define boundaries of information flow "within these clusters, information flows freely, while across clusters information flow is restricted by the limited connectivity available across clusters" (Himelboim et al., 2017). Typically, people with similar interests, and socioeconomic or demographic interests cluster. The density of a network describes the interdependency of the individuals; low density refers to individuals that are loosely connected while high density implies highly interlinked users. Network density is interesting because the "extent to which a network is densely interconnected affects the rate of information flow within it" (Himelboim et al., 2017). Centralization refers to the "degree to which connections are aggregated around just a few actors in the network" and gives information on hierarchical or egalitarian character of information flow (Himelboim et al., 2017). Modularity "captures the extent to which clusters are disconnected from one another, distinguishing between networks with divided vs. unified structures" (Himelboim et al., 2017). Isolates are users who are not connected to other users in the network and therefore excluded from the information distribution process.

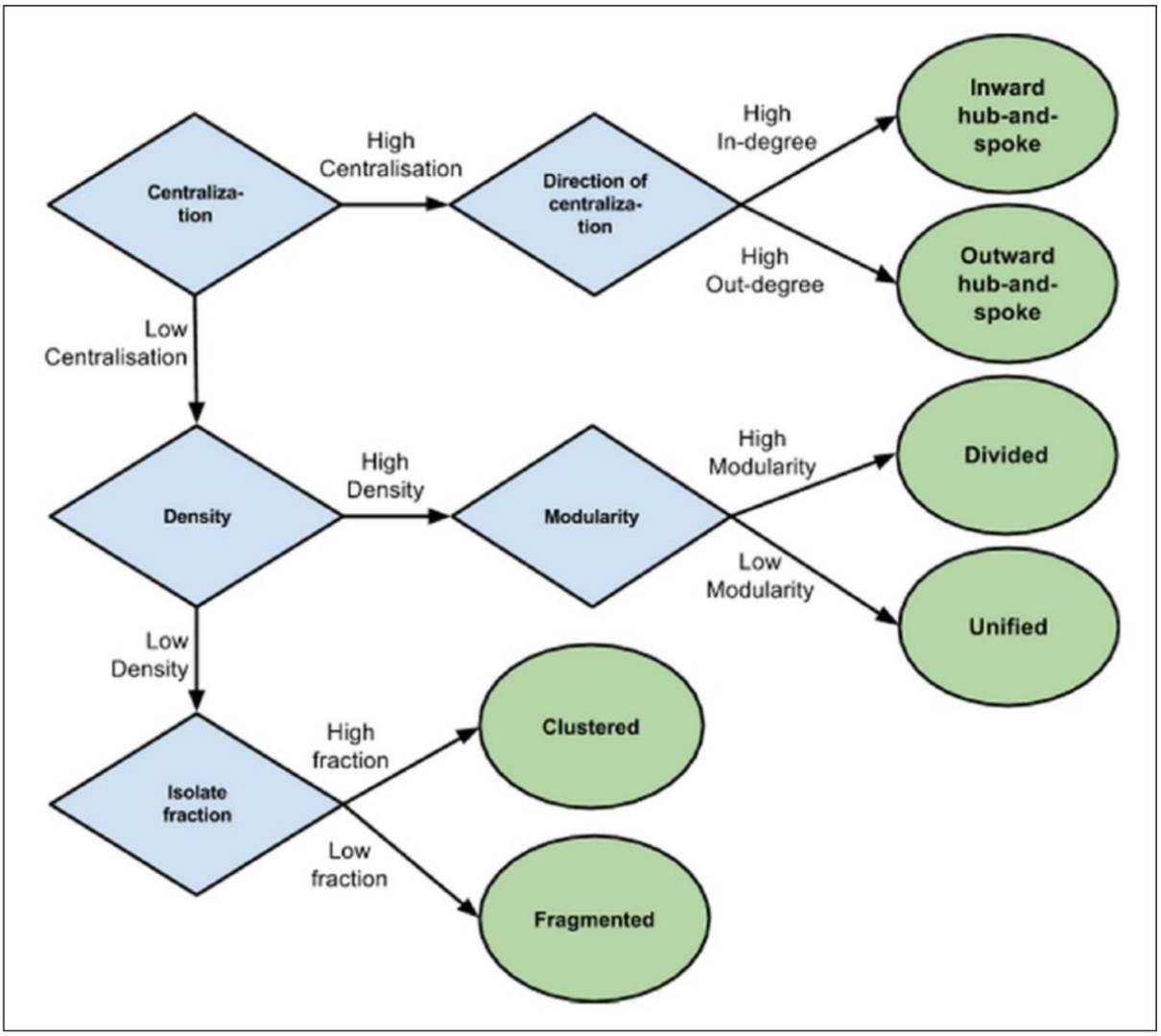


Figure 2: Twitter structure classification process (Himelboim et al., 2017)

The thresholds guiding the classification process identified by Himelboim et al. (2017) can be found in Table 5 and will guide the upcoming social network analysis. Specifically, the values for each day will be classified according to these boundary values.

Table 5: Boundary Values for Twitter structure classification process

Metrics	Boundary Value (low < value < high)
Centralization	0,59
Density	0,12
Modularity	0,29
Isolates	0,19

Figure 3 shows the operationalization and data analysis model, summarizing the steps taken to answer the individual sub-questions. Stakeholder-Analysis refers to the first sub-question, content-analysis to sub-question 2, and the process analysis aims to answer the last sub-question. The questions mentioned

in the figure enable additional comprehension of the sub questions, while the lower boxes include the analysis steps for each sub question.

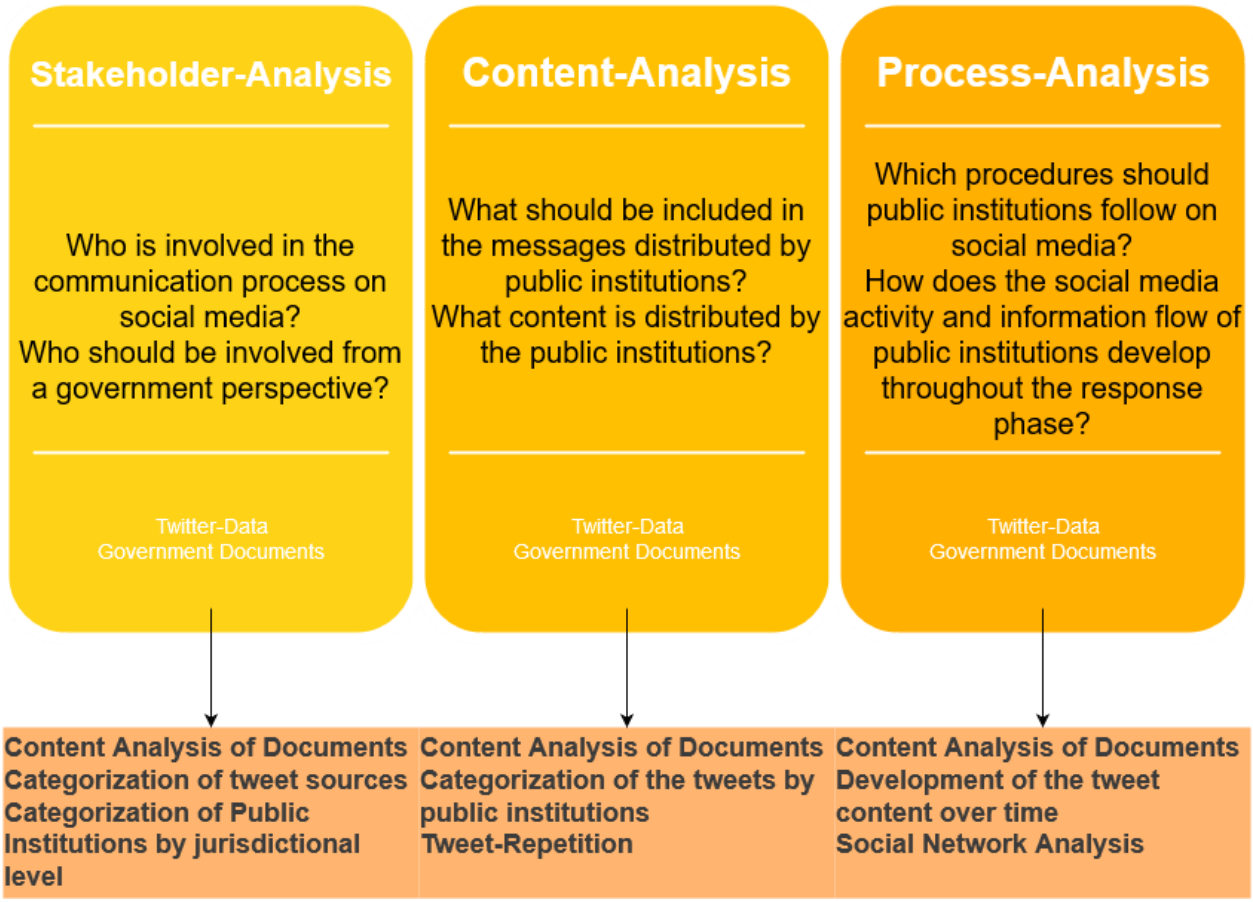


Figure 3 Operationalization and Data Analysis Model

The overall outcome of this analysis is a deep understanding of the social media communication process during Hurricane Harvey, with emphasis on the behavior of public institutions and officials, and their legal incentives.

Chapter 4: Results

Before presenting the results answering each sub-question, the very low frequency of social media related terms in all investigated documents can be seen in Table 6. The finding, that social media is rarely considered in the documents, will be considered throughout the following presentation of results. To put this in a broader context, it is advisable to mention that each document includes more than 100 pages, implying a minimum of 15000 words. This provides better understanding of the upcoming table, and the significance of the low frequency.

Table 6: Frequency of social media related terms in the government documents

Word/Phrase	Frequency
Social Media	11
Twitter	1
New Media	2
Internet	25

4.1. Stakeholder Analysis

This part of the analysis is guided by the first sub-question:

What are the differences between the stakeholder involvement in the social media communication process foreseen by the official plans and guidelines, and the stakeholder involvement visible on social media in the case of Hurricane Harvey?

4.1.1. Results from the Analysis of Government Documents

Stakeholders involved in the disaster communication on social media are individuals or organizations affected by the event. This implies all levels of government, the private sector, and nongovernmental organizations (DHS, 2013). The RFIOP (FEMA, 2016b) identifies the same key stakeholders but additionally specifies and differentiates the general public into two groups: the affected and non-affected public. The plan also refers to the media as one of the key stakeholders in emergency management and communication. According to the NRF, personally affected are emergency management representatives, community leaders, and government officials.

Examples of non-governmental organizations, such as the American Red Cross, or National Voluntary Organizations Active in Disaster constitute another group of relevant stakeholders in both emergency management and communication (DHS, 2008, 2013). The private sector can also be a valuable asset when it comes to communication and information sharing efforts during the event, since this may increase the reach of information dissemination (DHS, 2013).

When it comes to government stakeholders, all examined documents refer to the different levels including local, state, federal, tribal and territorial agencies and representatives. From the perspective of the state of Texas, mayors and county judges serve as emergency management directors and the Texas Department of Public Safety is the lead agency in the area of disaster communication (Texas Emergency Management Executive Guide, 2017).

None of the available government documents specifically refer to social media communication in the context of stakeholders, but describe and disperse more general roles and responsibilities regarding emergency and disaster management and command. Bearing in mind that events such as big natural disasters include and engage more than one jurisdictional level in the response management and operation, the question of responsibility and authority arises.

In general, the responsibility is managed and handled at the lowest jurisdictional level capable of handling the mission, which is commonly described as the subsidiarity principle. This is stated in both the NRF and the NIMS. For example, “the chief elected official of a local government has the legal authority to order the evacuation of areas within the governments jurisdiction that are at risk from or have been impacted by a disaster” (Texas Emergency Management Executive Guide, 2017). This does not imply that the lowest jurisdictional level solely possesses the power and authority. Quite the contrary, all departments and agencies are required to cooperate with one another and other state, federal, local, tribal, territorial and insular governments to the maximum extent possible (FEMA, 2016b).

The decision on the engagement of federal agencies is made in accordance to the Stafford Act, which defines whether federal support is required. If it is, the Federal Emergency Management Agency (FEMA) coordinates the assistance and leads the management and maintenance of situational assessment, planning, public information and warning. This implies not only the attempt but also the support and facilitation of multiagency planning and coordination by the federal level (DHS, 2013). “FEMA helps to unify the efforts of all responders around a common communication goal supporting the emergency management decision makers” (DHS, 2008).

The Harrison County Flood Control District (Harris County Flood Control District) summarizes the responsibilities of the different jurisdictional levels during Hurricane Harvey. Two federal agencies, the U.S. Army Corps of Engineers and FEMA claim to provide support to the regional and local agencies such as the Harris County Flood Control District, Harris County public health services, Harris County Sheriff’s Office, and local fire and police departments. Such an allocation of competences and authorities leads to assumption that Hurricane Harvey was an event falling under the Stafford Act, requiring federal support.

This classification of responsibilities is evidently made from a Harris County perspective but can be applied and extended to the other affected regions.

Disasters require a unified response from all agencies, the private sector and NGOs to prevent confusion and disorientation. This is enabled through “unified command”, which refers to a clear understanding of roles and responsibilities of all organizations involved (DHS, 2013). Every engaged agency sustains its own authority, responsibility for its own programs or policies, and accountability (DHS, 2013). The NIMS lists the following advantages of unified command: single set of objectives, improvement of information flow and coordination, joint understanding of priorities and restrictions, no agency´s legal authorities will be compromised or neglected (DHS December 2008). An important focus of this unified command should always be the development of lines of communication between all organizations involved, enabling effective information (FEMA, 2016b). In how far this was achieved during Hurricane Harvey will be further investigated when answering the second sub-question.

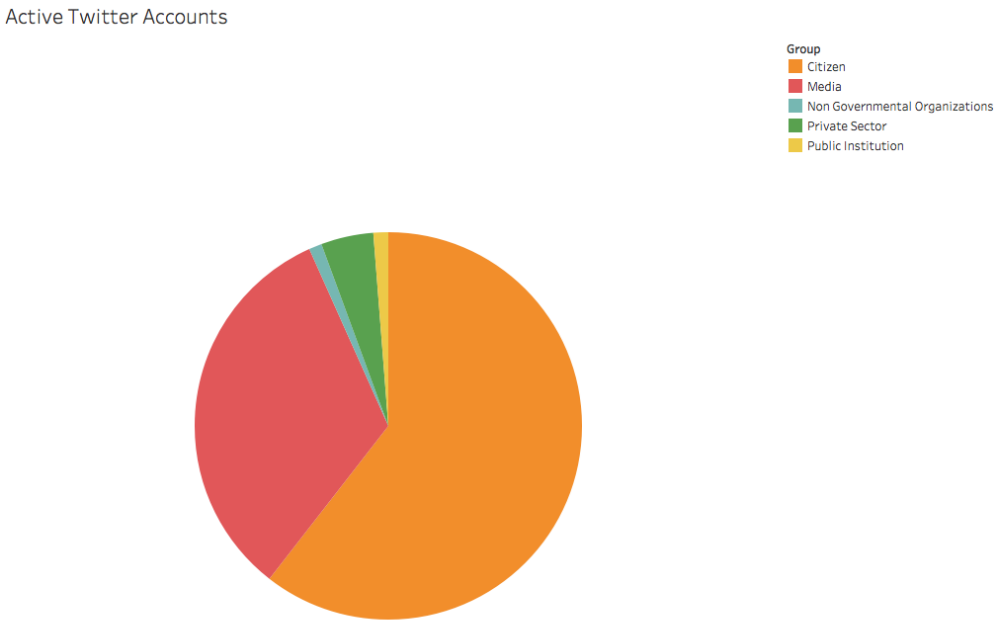
The NIMS requires jurisdictions to have outreach programs to promote public education. Government representatives, such as elected or appointed officials, are responsible for providing appropriate information to the public (DHS, 2013). For example, the NRF requires the affected Governor to address all members of the community during the disaster to help all individuals and organizations cope with the disaster and its impacts. Such behavior is in line with FEMA’s “whole community approach” and the principles of understanding, engaging and strengthening the community (DHS/FEMA, 2018). The engagement of the community improves the situational assessment and therefore the effectiveness of operations. Responsibilities of the people are the contribution of knowledge and skills (DHS, 2013), which was also emphasized in the literature review. They are also required to observe disaster communication and follow official instructions.

The government documents are relatively vague in the sense that any clear and specific assignment of responsibility is circumvented. Nevertheless, an overview of the required and affected stakeholders is provided, as is a general impression of authorities and responsibilities. As a next step, the stakeholders involved in the disaster communication during Hurricane Harvey will be identified using graphical representation of the Twitter data.

4.1.2. Results from the Comparison of Twitter Data and Government Documents

The graphical representation of stakeholder involvement in the communication process during Hurricane Harvey is influenced by the previous document analysis. All documents indicate five main groups of stakeholders: citizens, non-governmental organizations, the media, the private sector and public

institutions. This is supported by the several scholars, such as Haddow, G. and Haddow (2014). Within this next part of the analysis, these groups were used to label and categorize all Twitter accounts that published tweets during Hurricane Harvey. The result of this categorization is shown in Figure 4.



Citizens	61%
Media	33%
NGOs	1%
Private Sector	4%
Public Institutions	1%

Figure 4: Active Twitter Accounts shares

Figure 4 shows the share of active Twitter accounts categorized by the previously identified stakeholder groups during the hurricane. Visibly, citizens constitute the largest group of stakeholders (61%), supporting the emphasis on community involvement made in the government documents and the academic literature. This high citizen activism indicates a high communication need from a citizen perspective, which seems to be largely satisfied by the media with a share of 33%. The share of active public institutions active in social media communication during the hurricane is strikingly small with only 1%, same as the share of Non-Governmental Organizations (NGOs).

Before interpreting this distribution, another important part of the Twitter data should be considered. As mentioned in the literature, participants in a social media communication process characterize as sources and receivers of messages simultaneously (Nepal et al., 2015). It is therefore very interesting to take the “mentions” within the tweets into consideration just as much as the actual activity as sources of social media messages. Mentioned accounts are specifically approached and addressed by another stakeholder; they become receivers of a message. Figure 5 opposes the actual social media involvement of the different stakeholder groups and the number of approaches of these groups, indicating a call for involvement and further communication. Specifically, this comparison illustrates discrepancies and

similarities between the communication involvement desired by social media users and the actual social media activity of the individual stakeholder groups.

As mentioned before, NGOs Public Institution play the smallest active part in social media communication during the hurricane. This fact contradicts the impression given by the government documents, which specifically emphasize that these groups constitute important actors in emergency and disaster management and therefore communication (DHS, 2008, 2013). The findings do support the instructions and guidelines by the government documents that call for more communication activity of these institutions, in the sense that there seems to be a significant desire for public institution involvement in the communication process on social media. This is indicated by the share of addressed public institutions of 14%.

The observation that the media, although being highly involved in the social media communication with 33%, does not live up to the expectations of the social media users (41%). This supports the argument and emphasis put on media involvement by the government documents (FEMA, 2016b). Previous findings of scholars indicate that official public institutions are perceived to be more credible for disaster communication than unofficial sources, both via traditional and social media (Andersen & Spitzberg, 2010; Wogalter, 2006). The use of media for further indirect distribution of government messages is therefore a common approach and might explain the high involvement of the media. Another explanation for the large amount of media mentions can be the distribution of media content, accompanied by media mentions to give this distribution more credibility.

Overall, this contrasting juxtaposition indicates that organizations, public, private and non-governmental, lack behind in their communication involvement on social media. Citizens take the lead in the communication process. The fact that this group of stakeholders is significantly more active than actually desired and called for by the social media users, supports the assumption and focus made in the government documents that citizen involvement is a key step for efficient emergency management (DHS/FEMA, 2018). The Twitter data indicates that citizens are actively seeking support and information from other stakeholders.

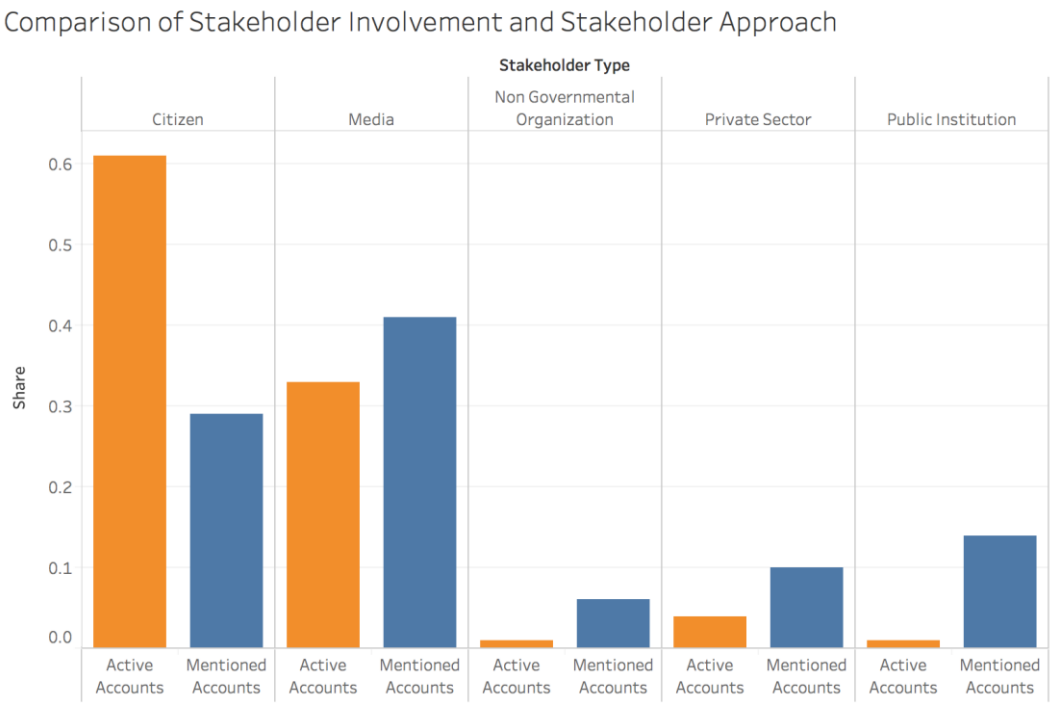


Figure 5: Comparison of stakeholder involvement and stakeholder approach

The findings indicating large discrepancies between actual and desired involvement of public institutions support the further analysis of this particular stakeholder group, going hand in hand with the research objective of this thesis. A closer look at both the active and mentioned accounts of Public Institutions is therefore the next step. As mentioned in the previous government document analysis, public institutions from all jurisdictional levels engage in the disaster management process, also in communications. For further analysis, four main levels are identified and derived from the previous document analysis: local, regional, state and federal. The local level includes community and city agencies, and the regional level refers to counties and areas. State level in this case is focused on agencies of the state of Texas and the federal level includes all specifically national and federal institutions. The results of the categorization of the active and mentioned public institution accounts are represented in Figure 6. One interesting result of this visual and quantitative comparison is the difference between the actual and the desired federal involvement. Federal activity, although being one of the most active jurisdictional levels with 36%, does not fulfill the desired involvement of 61%. This indicates a larger desire for federal involvement in the social media communication process than provided. Local institutions seem to be more engaged, with 36% of the overall public social media activity, than they are asked to be by the social media users, with 18% of the mentioned public institution accounts. This high activity of local agencies can be explained with the claim of Graham et al. (2015) that “social media is no privilege of the national government and its agencies, but especially during a disaster, the local component plays a significant role”. The same

applies to the regional level, even to a higher extent. The share of active regional agencies and institutions (20%) is more than twice as large as the desired share of 6%.

Comprehension of these relatively extreme differences may be provided in the findings from the document analysis. Federal involvement is dependent on the Stafford Act (DHS, 2013). As investigated earlier, Hurricane Harvey falls under this act due to the extent and reach of the disaster. This implies more federal involvement in the disaster communication, being an inevitable part of disaster management. Support for this procedural call can be found in the mentions of the Twitter data. In the area of social media communication this federal support is not sufficiently provided, indicated by the significantly lower social media activity. Statements found in all government documents call for the principle of subsidiarity (Texas Emergency Management Executive Guide, 2017), which supports the reservation of the federal agencies social media activity and the high involvement at the local level. Local agencies and representatives are specifically encouraged to take responsibility and be active in the communication process in the government documents. Additionally, county judges are told to engage in disaster communication, which they do according to the Twitter data. The findings of the Twitter data analysis indicate that this is not necessarily efficient, since the social media users rather approach organizations from the federal level than from the local or regional jurisdictional level. Findings on public institutions from the state level are comparable to the ones regarding federal agencies, their actual social media involvement (8%) does not live up to the desired activity (15%). The government documents at hand support the desired activity by calling for more involvement, appointing the Texas Department of Public Safety as the lead agency and requiring the affected governor to address the public during the disaster.

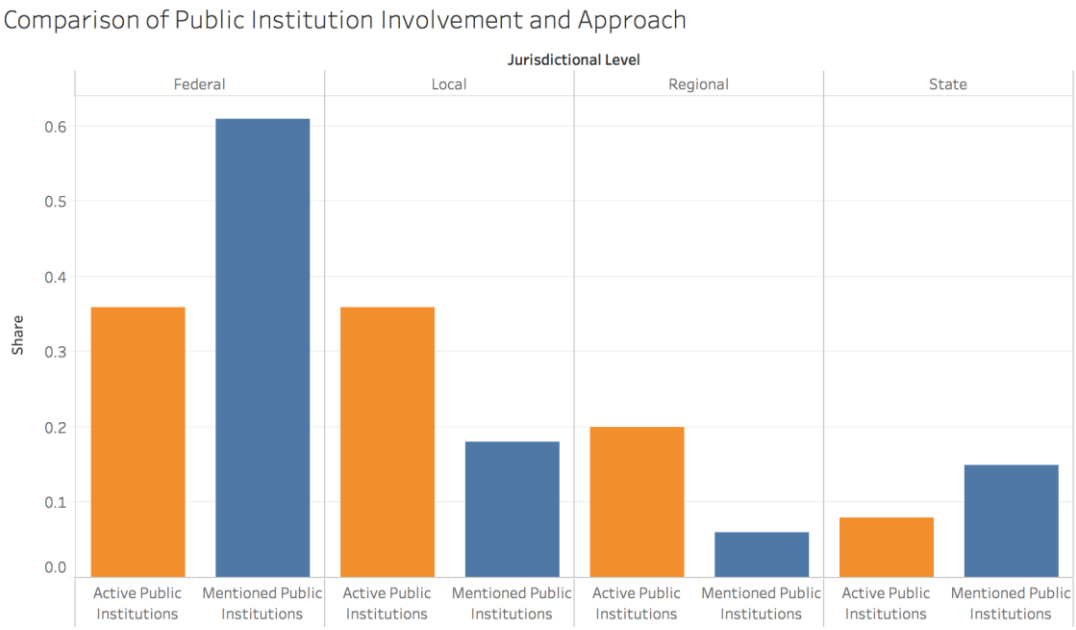


Figure 6: Comparison of Public Institution Involvement and Approach

Appendix A shows the most frequent mentioned and active public institutions extracted from the Twitter data, sorted according to their jurisdictional level. It provides a tabular summary of the previous comparative analysis of the government documents and the Twitter data, visualizing the major differences and similarities. This supports the foregoing quantitative analysis and gives additional insights into the specific accounts representing the different jurisdictional levels. Interestingly, the active accounts representing the federal level are often related to specific professional positions, rather than agencies. Examples are the strategic planner of FEMA, the Senator of Texas, the Chief of the National Guard Bureau Content Analysis and Texas State Representatives. Also, the active accounts of specific agencies are not coherent with the agencies specifically mentioned in the official documents. Both, FEMA and the U.S. Army Corps of Engineers did not activate their Twitter accounts sufficiently. The same applies to agencies of the regional level, such as the Harris County Public Health services and the Harris County Flood Control District. Examples for clear similarities between document and Twitter data, are police and fire departments on a regional and local level. However, one peculiar agency, the National Hurricane Center, repeatedly occurs in mentioned and active accounts but is not considered by any relevant government document in the context of disaster communication.

4.2. Content Analysis

The results of this part of the analysis aim to answer the second sub-question:

What are the differences between the content of disaster messages recommended in official guidelines and the content of social media messages disseminated by public agencies during Hurricane Harvey?

4.2.2. Results from the Analysis of Government Documents

As shortly mentioned in the first sub question, the principle of "unified command" (DHS, 2008) should guide disaster and emergency management at all times and in all areas. Applied to communication, this includes unified messages, common terminology and fixed lines of communication (DHS, 2008; FEMA, 2016b).

The government documents at hand require the responsible agencies and officials to disseminate messages with specific characteristics. The results of a content analysis of these documents are summarized in Table 7.

Table 7: Message characteristics demanded in the government documents

Message Characteristic	**Government Documents**			
	National Response Framework (DHS, 2013)	The Federal Emergency Management Agency – Publication 1 (FEMA, 2016a)	Local Mitigation Planning Handbook (FEMA, 2013)	National Incident Management System (DHS, 2008)
Clear and accurate	X	X	X	X
Culturally appropriate	X	X		
Plain language	X			X
Common terminology				X
Realistic		X		
Align with community values			X	

In addition, the content analysis of the government documents resulted in a collection of topics that should be distributed by the public institutions. One priority should be the distribution of general information and facts about the incident, which is the "key point in the release of public information" (DHS, 2008). This includes "critical lifesaving and life-sustaining information" (DHS, 2013), information on incident cause and size (DHS, 2008, 2013; DHS/FEMA, 2018), the current status of the incident (DHS, 2008, 2013; DHS/FEMA, 2018) including damage and restoration estimates (FEMA, 2016b). As second topic of the messages ideally are instructions from the public institutions to the citizens including health

risk warnings, pre-incident recommendations, evacuation guidance, protective measures (DHS, 2013), emergency alerts and warnings (DHS, 2008; Texas Emergency Management Executive Guide, 2017) and encouragement to volunteering and participation in the response efforts (Texas Emergency Management Executive Guide, 2017). Thirdly, messages should include information on actions taken by public institutions and representatives, meaning the assistance being made available, information on the delivery of emergency services, accessible tools and resources committed (DHS, 2008, 2013; FEMA, 2016b; Texas Emergency Management Executive Guide, 2017). Also, information on authorities and their responsibilities may be distributed in messages coming from public institutions (FEMA, 2016b). Overall, one can derive three main message topics out of the government content: information on the disaster, information on the actions taken, and instructions given by the public institutions. These three topics reflect the statement of Haddow, G. and Haddow (2014) that response communication should include warnings, evacuation appeals and reports on the current situation.

4.2.3. Results from the Comparison of Twitter Data and Government Documents

The three types of content distributed by public institutions during the disaster previously extracted from the relevant government documents are used to analyze the Twitter data on public institution involvement. After assigning each tweet of this dataset to one of the three categories, the results shown in Table 8 were obtained.

Table 8: Content type and their share in the tweets during the disaster by public institutions

Content Type	Presence in the Messages
Information on the event	0.45
Instructions on appropriate behavior	0.28
Actions taken	0.27

As Table 8 shows, almost half of all messages distributed by public institutions are categorized as *Information on the event,* while content on *actions taken* and instructions was published to a very similar extent. These findings are in line with the statements made in the government documents, stating that incident information and updates on the event should be the top priority. This is also accordance with theory part of this paper stating that an informed public is more likely to engage in appropriate behavior and that information on the incident enables them to make their own risk assessment (Lin et al., 2016).

Another part of the Twitter analysis is the search for messages indicating the unified command. A screening of the data for identical messages distributed by different institutions resulted in the

identification of the repeatedly published messages presented in Table 9. Interestingly, almost all messages only occur in these results because they have been posted repeatedly by the same institution. This does not indicate unified command as recommended in the government documents; on the contrary it hints at unilaterist communication strategies of the individual agencies. Evidence for unified command and fixed messages is given by the tweets published by the fire department of Houston and the Harris County OHSEM. These institutions seem to align their communication strategies, setting an example for the cross jurisdictional cooperation desired by the government documents.

Table 9: Messages Repeated by Public Institutions

Content Type	Sources	Tweets	Repetitions
Information	1. Fire department Houston 2. Harris County OHSEM	A message from @FriendswoodCity regarding Hurricane Harvey and its effects on the area.	2
		"ICYMI: Hurricane #Harvey makes landfall, severe flooding possible for Harris County."	2
		Hurricane # Harvey Now a Category 2 Hurricane, Continues to Strengthen.	2
	1. Senator of Texas	For more information on how to prepare for #HurricaneHarvey visit here: (website)	2
Instructions	1. Public Utility Commission of Texas	"Be Prepared! Recovery after an outage!"	8
	1. Assistant Secretary for Preparedness and Response (ASPR)	Do you rely in electricity powered medical equipment? If #Hurricane Harvey is coming your way, charge your equipment now.	2
	1. Fire department Houston 2. Harris County OHSEM	Hurricane Harvey Rapidly Strengthening, Residents Urged to Prepare.	2
	1. US Consumer Product Safety Commission	Lost power? Using a portable generator? Make sure you have working CO alarms. #Harvey2017 #HurricaneHarvey #invisiblekiller	2
		Mayor @ Ron_Nirenberg and @ Judge_wolff will provide an update on # HurricaneHarvey at 1:30pm. Watch live at (website)	2
		Home fires, explosions are all things to watch out after a storm #Harvey2017	3
Actions taken	1. Fire department Houston 2. Harris County OHSEM	@ HomelessHOU is hard at work coordinating the local homeless system's preparations for Hurricane # Harvey.	2
		Follow us on Snapchat for more Hurricane #Harvey updates and to see what is happening at the Emergency Ops Center NOW	2
	1. Assistant Secretary for Preparedness and Response (ASPR)	@HHSgov readies #public health & medical support in Texas & Louisiana ahead of #Hurricane Harvey	2

Additional insights are provided after analyzing the Twitter data regarding the word count of the tweets. This provides information on the message characteristics *Clear and Accurate* demanded in the government documents, which specifically refer to short and precise messages. The mean number of words in the tweets by the selected public institutions is 17,62, while the mean character count is 146,32. According to quantitative analysis of the most accurate and effective tweet messages, the ideal length of tweets is smaller than 100 characters "tweets that contain less than 100 characters receive

17% higher engagement than longer Tweets" (Buddy Media, 2012). This threshold is evidently exceeded by the mean character number of the public institutions tweets. This indicates a lack of clearness and accuracy and is one difference between content recommended in official guidelines and the content of social media messages disseminated by public agencies.

At this point, it must be stated that the other characteristics identified in the government documents cannot be measured and compared with the Twitter data at hand. This especially applies to linguistically appropriate, realistic, and the alignment with community values due to the fact that any evaluation of these traits would only be speculative and impossible to validate neither qualitatively nor quantitatively.

4.3. Process Analysis

This part of the analysis is led by the last sub-question:

What are the differences between the targets regarding continuity and accessibility of the communication process advocated in official guidelines and the quality of the communication process provided in the social media communication during Hurricane Harvey?

4.3.2. Results from Document Analysis

The Department of Homeland Security chronologically describes the most relevant steps to be taken in the disaster communication process in the NIMS (DHS, 2008). In order to provide information to the public and other external stakeholders, the relevant knowledge needs to be gathered. As explained in the NIMS, this is achieved through "on-scene command", "on-scene public information officers", "media monitoring", "news media" and "public and elected officials" (DHS, 2008). This is in accordance with the claim made by Coombs (2010) that decisions on further proceeding and the formulation of messages can only be made once the responsible authorities understand the situation within the community. The next step is the verification of the collected information through other public information officers in the Joint Information Center and on-scene. This is followed by coordinating the information, including the establishment of key messages: "after gathering information from all sources, unified messages are crafted that address all informational needs and are prioritized according to the overall federal, state, tribal and local response strategy" (DHS, 2008). The messages should give consistent and timely information to the right people. Before the messages can be disseminated they need to be cleared and approved by the main authority "ensuring that the information is consistent, accurate, and accessible" (DHS, 2008). However, this should take place quickly, to ensure a rapid and timely information release (DHS, 2008; FEMA, 2013, 2016a). Multiple channels should be used to disseminate the messages, bearing in mind that not all options might be available during a disaster. Informing the media through phone

calls and interviews enables them to publish the information in a timely manner and reach their audience. Direct communication can be facilitated through personal visits or town meetings by the elected or appointed officials (DHS, 2008), and by activating the social media accounts of the public institutions.

The local Mitigation Planning Handbook (FEMA, 2013) names social media as one out of several methods for information distribution. Twitter messages serve the purpose of reaching out to the public during the planning process of the official disaster response, improving public awareness through one-way-communication and get situational awareness via two-way-communication (DHS, 2008; FEMA, 2013, 2016a). Especially this second part of public outreach should begin once the risk assessment is complete and the planning teams create the mitigation strategy. Involving the public at this stage provides the opportunity to educate them on the risk assessment of findings, collect input on any data inaccuracies and understand the situation. One very important characteristic of the disaster communication process relevant in this context is its inclusiveness and accessibility to all (FEMA, 2016a). All documents at hand emphasize the importance of accessibility in the context of the communication process, implying the need for communication channels with a high reach (FEMA 2016). The official FEMA publication (FEMA, 2013) states, that all survivors are entitled to equal access to all programs and services. Equality implies that characteristics such as age, functional capabilities, socioeconomic characteristics and language do not influence the access. In this context “social media outreach” is referred to as one key tool to ensure this equal accessibility (FEMA, 2016a). Incident related information should therefore be distributed through mass media and social media (FEMA, 2016b). The RFIOP encourages the responsible public institutions to coordinate the first release of information to the public, also by establishing social media messaging, within the first hour of the incident.

4.3.3. Results from the Comparison of Twitter Data and Government Documents

As mentioned in the results of the second sub question, there are three broad topics that should be distributed by the public institutions in the communication process, according to the government documents at hand: information on the event, instructions and information on the actions taken. All of these should be distributed consistently and timely (FEMA, 2016a). Consistence refers to continuously ongoing public education and outreach during and after the event (DHS, 2008).

The main process related message characteristics that can be extracted from this document analysis are accessibility, consistency and timeliness. This result is in line with the findings of previous research (Alexander, 2014; Coombs, 2010; Hallahan, 2010; Houston et al., 2015; Liu et al., 2016).

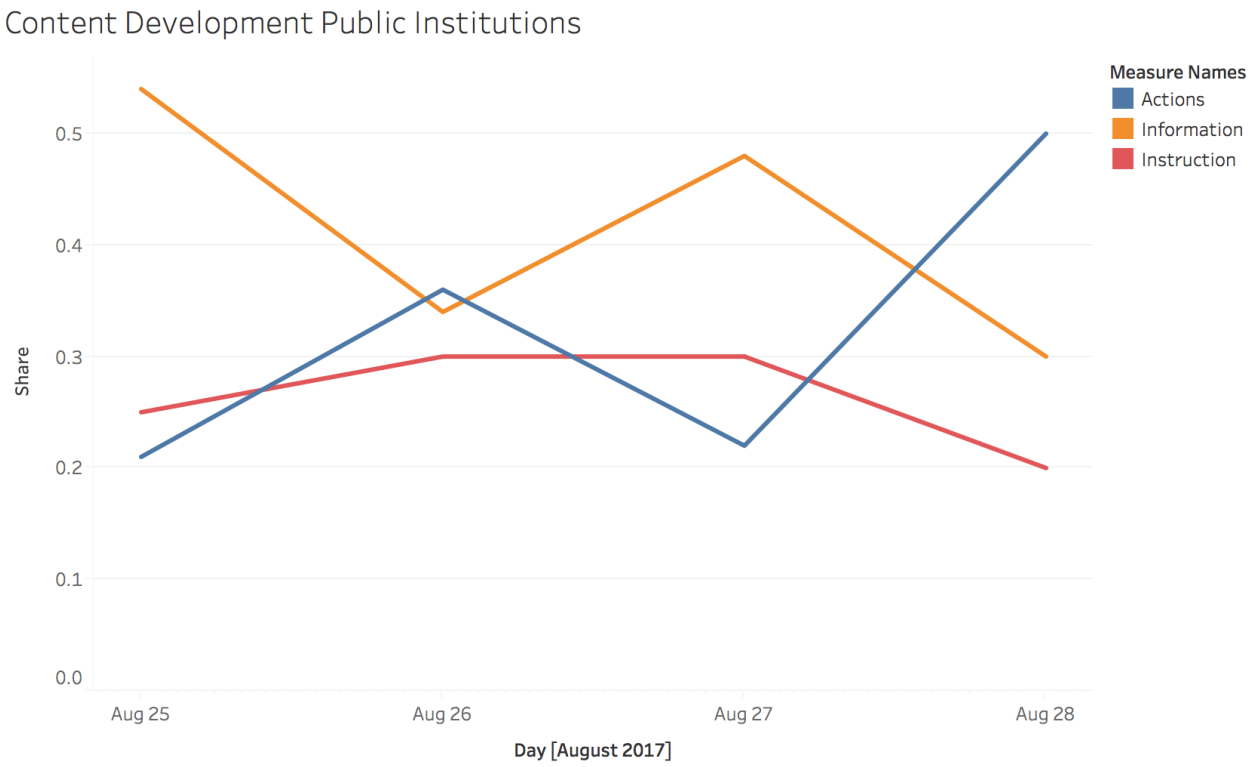


Figure 7: Content Development Public Institutions

Figure 7 shows the presence of the topics information, action and instruction in Twitter messages posted by public institutions during the hurricane. The x-axis provides a time scale, showing all four days of the analysis (25.08.2017 till 28.08.3017). The y-axis applies the share of the individual topic in all tweets published by public agencies. The graph provides the following results and gives information on the development of the individual topics and about their relations.

The share of messages on *actions taken* drastically increases within the four days of the event. Explanations for this increase can be found in the results of the previous document analysis, stating that actions - general disaster response, and communication strategies - need to be developed and coordinated among the responsible agencies. Information on these strategies is therefore rather limited during the first hours of the disaster and increases when the event is coming to an end, also due to the fact that actions need to be taken first before information on them can be distributed.

Information goes through a very different development. Its peak is located at the first day of the event, followed by gradual, but relatively slow decrease. Nevertheless, it is always one of the most present topics in the tweets of the public institutions, which reflects the results of the document analysis in the

second sub-question that general information on the incident is the first content available and relevant to enable the public to assess their own situation and affectedness and take action. This result also meets the demanded principle of timeliness, since the public institutions immediately publish information on the event. With the passing of the disaster, the need for information on it decreases.

Messages including *Instructions* show the largest consistency in the communication of the public institutions, with a share ranging from 0,2 to 0,3. One can observe a slight increase of instructions distributed during the middle two days, and a decrease at the last day of the disaster. This increase can be explained by the unified command and cooperation between jurisdictional levels mentioned in the government documents. After coordinating themselves during the first hours of the event, the public institutions are able to publish content on the actions they take to respond.

A comparison of the three topics show that not all of them are consistently distributed throughout the process, although this is a key requirement in the government documents. Nevertheless, all topics are present through the process, indicating continuity.

In order to determine in how far the accessibility principle is provided in the social media environment, an SNA was conducted and interpreted by applying the work of Himelboim et al. (2017).

The results after applying the framework of Himelboim et al. (2017) indicate that the social Twitter network can be classified as clustered on all four days, as can be seen in the metrics and values presented in Table 10. The clusters or communities can be identified in the visualization through the different colors. Each color includes nodes belonging to one particular group within the network. As mentioned in the literature review, clusters are subgroups of interconnected individuals. The groups resulting of such clusters define the boundaries of information flow “within these clusters, information flows freely, while across clusters information flow is restricted by limited connectivity available across clusters” (Himelboim et al. 2017). Clustered networks indicate inhibited information flow, since people don’t share a lot of information outside their clusters. There is a lack of central information source that, according to (Himelboim et al. 2017) indicates limited social media activity of the responsible accounts to unite the community clusters. In this case this indicates a lack of involvement of the public institutions throughout the communication process, which is not in conformity with the requirements of the government documents.

Clusters can be further interpreted when looking at specific values, communities or nodes. As indicated in Table 10, the modularity value exceeds the threshold of 0,29 at all times and reaches its peak on the 27th of August. The continuously high isolate fraction indicates an exclusion of individuals in the

communication process, since they have no or limited ties to the overall network. This affects the density of the network which is very low at all times. Centralization values give information on hierarchy within the information flow. The results show very small centralization values, implying an "egalitarian" pattern of information flow (Himelboim et al. 2017) – there are no highly influential hubs or gatekeepers. However, one can observe some slightly influential hubs with the help of the visualization of the networks.

Table 10: Network metrics for each day

	25th of August		26th of August		27th of August		28th of August	
Centralization	0,08	Low	0,07	Low	0,05	Low	0,04	Low
Density	0,00	Low	0,00	Low	0,00	Low	0,00	Low
Modularity	0,57	High	0,50	High	0,88	High	0.47	High
Isolate Fraction	0,46	High	0,49	High	0,49	High	0,69	High
Average Degree	1,66		1,48		1,36		1,16	
No of Communities	5		16		14		7	
Average Path Length	1,98		1,60		1,19		1,10	

On the 25th of August, as can be seen in Table 10, the number of communities is low compared to the other days. This implies that the network is composed of five main clusters or sub groups only, which gives disclosure in terms of the quality of the information flow. These can be identified in the visualization of the network in Figure 8 by looking at the colors. Each color represents one cluster or social group. The rather small number of communities, compared to the other days, implies a relatively effective information flow – the information needs to be disseminated to the five clusters and is further shared within the individual communities. This implies a better accessibility than on the following days.

This argument for a higher quality of information flow compared to the other days can be related to the effort of public institutions. The largest node with the highest betweenness centrality is the account of the president of the U.S., followed by the account of the Department of Homeland Security, the local TV channel abc 13 Houston and the regional newspaper Texas Tribune, and the two national media channels Fox News and CNN. Two of the nodes with high betweenness centrality represent social media accounts of public institutions: the President of the United States and the Department of Homeland Security. The betweenness centrality measure "identifies persons who are indispensable for information sharing between other persons" and provides these persons with the "potential to mediate the flow of

resources or information between other actors" (Kiesling et al., 2016). Relating this to the nodes representing public institutions, one result of the analysis is the finding that on the first day the President and the Department of Homeland Security played an important role in the information distribution process, raising the quality of the overall information flow.

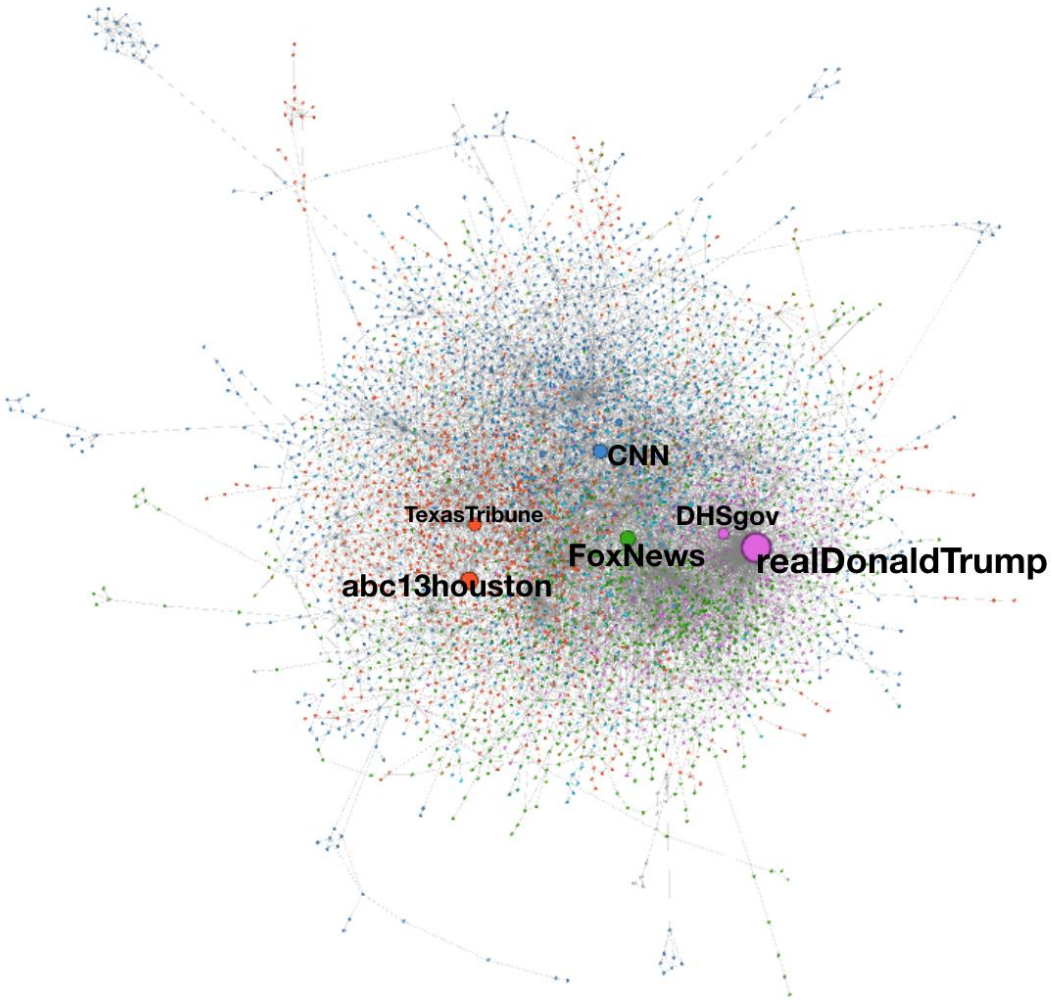


Figure 8: Visualization of the Social Twitter Network on the 25th of August 2017

As can be seen in Table 10, the number of communities increases to 16 on the 26th of August, indicating a more impeded information flow, since the information has to disseminated to all 16 communities or social groups to ensure accessibility for all active accounts. Again, each cluster is represented by a different color in Figure 9 and Appendix F.

Next to enabling the identification of clusters through colors, the visualization of the network in Figure 9 offers interesting insights into the accounts associated with the biggest nodes and therefore with the

highest betweenness centrality. As became clear in the previous interpretation of the network presented in figure 8, such nodes influence the information flow. Fox News, now the largest and most relevant node, is accompanied by three other national TV channels and two accounts related to the local channel abc 13 Houston. Public Institutions no longer play a visible part in the communication process and use their relevance and influence on the information flow. Instead the media prove to be consistent and irreplaceable in the process of communication sharing, supporting the findings of the analysis in sub-question 1.

Figure 9: Visualization of the Social Twitter Network on the 26th of August 2017

On the third day of the disaster, the 27th of August 2017, the number of communities slightly decreases (Table 10). However, considering that compared to the other days the number of 14 communities or social groups is closest to the highest value on the previous day, the assumptions and interpretations in the previous section can be applied here. The information flow is more impeded, when compared to the 25th of August.

Figure 10 and Appendix G provide visualizations of the network on the 27th of August, labelling the biggest nodes. Again, their identification discloses the accounts with the highest betweenness centrality. Fox News remains the strongest node, followed by abc 13 Houston and other media channels. Additionally, a new group of influential stakeholders is introduced: Non-governmental charity and aid organizations (Salvation Army, Save the Children, Charity Navigator). This implies that the media and the non-governmental organizations influence the quality of the information flow. Again, public institutions are not visible.

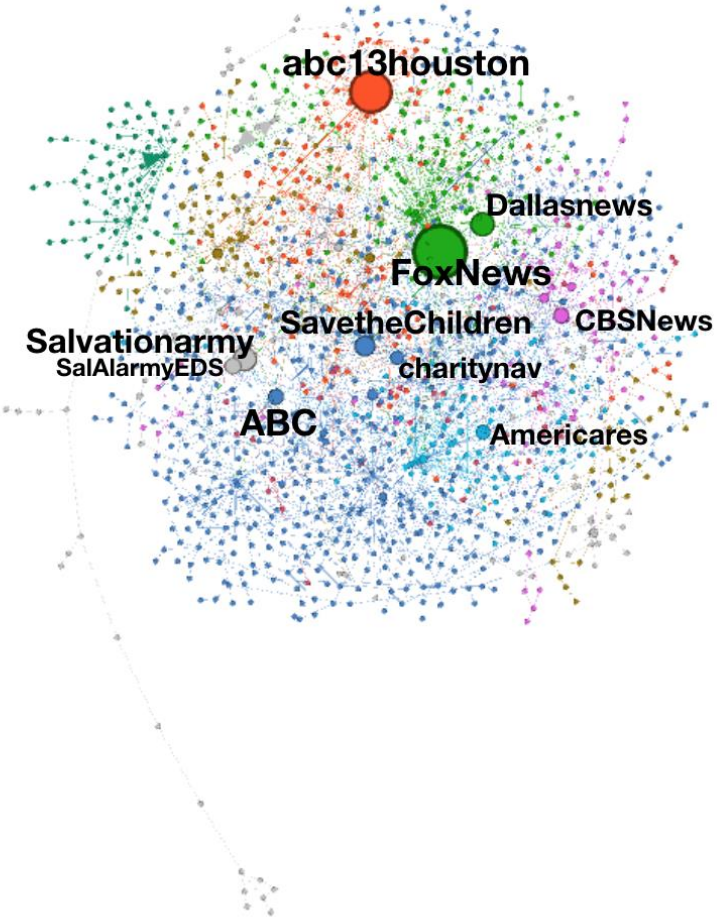


Figure 10: Visualization of the Social Twitter Network on the 27th of August

As can be seen in Figure 11, public institutions reappear in the group of nodes with high betweenness centrality on the 28th of August In the form of the Texas State Senator John Cornyn. This node is accompanied by Fox News, other media sources (WTAE, WFMY, OANN, kticountry, variety, Newshour)

and non-governmental organizations. For the first time in the four days, citizens appear to be play a relevant part in the connection of communities and individuals during the communication process.

Since the number of communities is relatively low compared to the values of the previous days, the information flow in this network appears to be more fluent and effective (Table 10). Interestingly, the comparison of the four networks give room for the assumption that the presence of a public institution account is related to the number of communities. However, any further interpretation of this finding would be speculative.

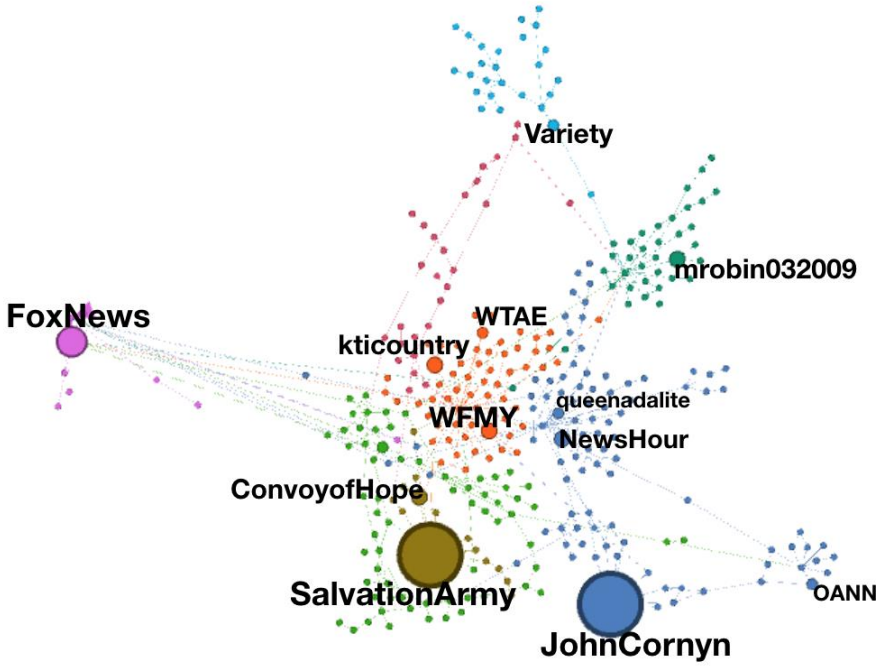


Figure 11: Visualization of the Social Twitter Network on the 28th of August

The results that can be gathered from these four networks support the claim that there is a lack of public institution involvement in the social media network. Also, support for claims by the government documents is given since the media, consistently plays a relevant and influential role. The consistent presence of local news channels supports the assumption of Peterson and Thompson (2010) that local news are the best news during an event. Interestingly, public institutions never play a role as such, but their personnel and representatives.

Overall the analysis of the Twitter data indicates constraints in the information flow, limiting the accessibility of information provided to tweets by public institutions. Taking into consideration that this is due to weak ties and connections between individuals and public instructions, the previously presented argument of Haddow, G. and Haddow (2014) and Andersen and Spitzberg (2010) that one centralized source is the key to effective disaster communication, is refuted. Instead the results of the SNA support the claim of Sellnow et al. (2009) that multiple communicators responsible for groups increase the reach and effectiveness of such communication, enabling larger accessibility. However, the Twitter accounts of media channels prove to be good channels for indirect distribution of government information, which supports the argument by Houston et al. (2015) that disaster warnings should be expressed by government agencies, followed by a dissemination through the mass media.

Chapter 5: Discussion - Implications and Recommendations

In order to reach the research objective and develop recommendations for policy- and decision-making in disaster communication, a short discussion of the results precedes the specific statements and formulation of specific suggestions.

Starting point of the discussion is one finding that continually accompanied the document analysis. Social media is considered to a very limited extent in the government documents. The guidelines and plans rarely mention social media or Twitter in their disaster communication strategies, or refer to it very shortly without further elaboration. Therefore, the basis of all upcoming recommendations is a stronger inclusion of social media in the official disaster communication strategies.

As indicated in the comparison of government documents and the Twitter data, public Institutions constitute the smallest stakeholder group, together with non-governmental organizations. This highly contradicts the requirements of the government documents regarding general disaster communication, indicating that a larger involvement and representation of public institutions on social media should be strived for. The finding that public institutions are addressed 14 times more than they actually engage on social media, supports this statement. Public agencies do not sufficiently use their credibility as an official source in the area of disaster communication via social media (Wogalter (2006), Andersen and Spitzberg (2010). To prevent the underrepresentation of public institutions, social media activity could be implemented as a fixed part of every communication strategy. This is evidently not the case at all, since government documents either do not mention social media at all or simply mention it in one sub-clause. However, one very active and frequently mentioned public institution, the National Hurricane Center, is not considered as a disaster communicator by the government documents, exhibiting an obvious lack of focus in this area. Possibly, this is due to a lack of focus on additional, specifically Hurricane related government documents. This should be investigated in future research. The results indicating a high activity of individual and position related official Twitter accounts, rather than specific agency-accounts give room for the assumption that this neglected person-specific area should be incorporated in the government documents.

Traditional media institutions on the other hand seem to play a very important role in the disaster communication on social media. Although media channels are highly engaged on Twitter, their activity does not seem to reach the, through mentions, desired social media presence. It is therefore no surprise that both the government documents and the existing literature underline the cooperation with traditional media houses to reach the masses and distribute information and warnings (Houston et al.,

2015). Although traditionally such media involvement referred to TV and radio channels, and newspaper publications; nowadays social media content published in the name of the very channels seems to have the same effect. Interestingly, the results of the SNA suggest that local media outlets play almost an equally influential and consistent role in the network as national papers and channels. From the public institution perspective, a step to make use of the influence of social media accounts of the media could be the specific coordination with the social media managers of the organizations to ensure quick and accurate information distribution. This indirect government social media activity could help to prevent the ignorance of government messages, feared by Luna and Pennock (2018).

Although data collection and situational assessment through citizen inclusion is indicated as a key part of disaster communication by both the literature and the analyzed documents, the Twitter data was not able to provide further insights. This is due to the fact that the collection and processing of the information given by the citizens, is happening offline – social media data analysis is not able to investigate in how far this was done. Nevertheless, the high social media activity of citizens gives ground for the assumption that they provide information interesting and relevant to the responsible agencies.

The in-depth analysis of the active and mentioned public institutions and the reference to the content of the government documents provides interesting insights into the required and actual social media engagement of agencies of different jurisdictional levels. For one, the actual Twitter activity of federal agencies is in line with the requirements and recommendations of the government documents. Nevertheless, this does not seem to be the extent of social media presence required by the social media users, indicating the actual need. This leads to the assumptions that the official guidelines and plans should lay more emphasis on federal communications activities, and maybe moving away from the subsidiarity principle. A similar statement can be derived regarding the Twitter activity of state level institutions. Again, the need – measured by the mentions – exceeds the requirements of the government documents and the actual social media activity. Although the institutions comply with the official rules and guidelines, more involvement could increase the communication effectiveness, indicating a need for adjusting the relevant documents. The comparison of Twitter and document data in the context of local and regional agencies on the other hand hint at a waste of resources, which may derogate the effectiveness of disaster management and -communication. This assumption is grounded on the fact that the local and regional public institutions provide more social media presence than required by the mentions, although this complies with the government documents.

The work of Resnyansky (2014) finds that one negative aspect of social media use in disaster communication is the involvement of 'too many' stakeholders. The results of the SNA support this statement. The lack of centrality and the clustered network structure give reason to assume that too many accounts are involved in the Twitter conversation on Hurricane Harvey, circumventing the identification of key information sources and of a smooth and far-ranging information flow. Additionally, the SNA gives insights into the accessibility of information. The high number of isolates indicated through the SNA shows that the principle of accessibility is not sufficiently met in the social media communication process during Hurricane Harvey. Isolates are excluded from the communication process and have no access to the information provided. Also, the number of communities ranging from 5 to 16, lead to obstacles in the information flow. This form of inequality of information accessibility between the social media users, adds upon the existing inequality caused by social media identified by Alexander (2014), Bertot et al. (2012), and Luna and Pennock (2018). A solution could be the engagement of multiple social media accounts and actors, rather than focusing on a centralized information source. This partly contradicts the appeal of the government documents for a "unified command", which is not sufficiently provided since the analysis results indicate a lack of unified messages and their repetition. Although the outcome of the analysis calls for multiple key accounts, the unified command should not be neglected when it comes to content development. This should be provided through the distribution of identical key information to prevent confusion.

Results regarding the content of the tweets give reason to assume that all relevant topics are distributed consistently and in line with official guidelines and requirements. However, the length of the tweets exceeds the ideal and most effective range. To ensure a clear and accurate information flow, social media content of public institutions should not exceed the character limit of 100. This is very important since the public needs to accurately comprehend the situation and the actions taken to make risk assessments, behave appropriately and increase the effectiveness of the disaster management.

The following recommendations build on the policy structure and offer suggestions for their improvement.

The results of the first sub question lead to the following recommendations:

1. Make social media communication a fixed component of the overall disaster communication strategy to ensure more social media activity of the public institutions.
2. Increase the coordination with the media, specifically the responsible social media managers to ensure a quick and accurate information distribution.

3. Put larger emphasis on the involvement of federal and state institutions on social media.
4. In the case of a hurricane, include the National Hurricane Center in the social media communication strategy.

The next recommendations are developed from the results of the second sub question.

5. Create key messages that are repeatedly distributed by all of these accounts.
6. Provide guidelines on tweet criteria such as their length which should not exceed 100 characters.

And the third sub question give room for the following recommendations.

7. Engage more Twitter accounts of public agencies during the disaster to ensure a higher reach and higher accessibility.
8. Encourage individuals representing public institutions to distribute information on their official social media accounts.

Chapter 6: Conclusion

This research aimed at answering the following research question:

To what degree do official disaster response communication guidelines and the social media activity of public institutions during disasters take the increased need for social media communication into account?

With the help of three sub questions and a comparative analysis this question could be answered and the research objective, the development of recommendations for policy- and decision-making in the field of emergency management and disaster communication was met.

The results support the statement of Bertot et al. (2012) that the agencies use social media through "an antiquated policy structure" that establishes the parameter for information flows, access, and dissemination. Accordingly, one answer to the research question is that the relevant disaster response communication guidelines do not sufficiently include social media communication. This reflects in the social media activity of public institutions during Hurricane Harvey, since this activity complies with the government documents. Concluding, the disaster response communication does not take the need for social media communication into account to the necessary degree, which is reflected in the selected case.

The great influence of disaster communication on the impact of the disaster should be highly prioritized by all stakeholders involved, including public institutions (Houston et al., 2015). Therefore, the implications and recommendations for decision-makers in the area of disaster and emergency management were developed from the results. These recommendations concern the content of the messages, the media cooperation and the involvement of the different jurisdictional levels. All of them follow the same pattern, requesting a higher inclusion of social media communication in the official disaster communication guidelines and procedures. This would also prevent "ad hoc" social media use of responsible agencies, as The Economist (2017) calls it in the context of Hurricane Harvey.

Besides the development of precise and easily applicable recommendations, this research contributes to the academic sphere. As mentioned earlier, most research on social media use in disaster communication is focused on the recovery phase and citizen involvement. This research however, chose to focus on the response phase and investigated social media use from a governmental perspective. Especially the inclusion of Twitter data offers interesting insights, which could not have been provided by a document or survey data based analysis. Instead, this research combines quantitative and qualitative research methods, simultaneously applying approaches from political sciences and computer science. This multidisciplinary approach is one major strength of this research.

However, this research is limited to some extent. For one, important aspects of the social media communication process during disasters have not been considered in the analysis. This includes the investigation of trolls and bots, the blame game, and the social media data collection of public institutions. These aspects were mentioned and explained in the literature review since their inclusion in the analysis was originally intended. However, this would have exceeded the given time and volume of a bachelor thesis, and the computational skills of the researcher. An additional limit of this research is the sole focus on Twitter data, excluding other social networks, such as Facebook or Instagram. The decision on Twitter as the only social media data source was made to focus on the most used platform during Hurricane Harvey. Future research on other social media platforms during Hurricane Harvey could lead to the development of additional recommendations. An investigation on threats caused by social media, such as trolls and bots, could also provide additional insights on how governmental authorities can cope with them during disasters. Besides these recommendations that are based on social media data, one suggestion is conducting a survey-based analysis on how far public institutions make use of social media themselves to assess the situation and the sentiment of the public. It could also be very interesting to investigate the possible relation between the number of communities in a social media network during a disaster and the betweenness centrality of public institutions within this network, as discovered in the process analysis. Moreover, a study relating the social media behavior of public institutions to the "offline" world could provide further support and credibility to this research.

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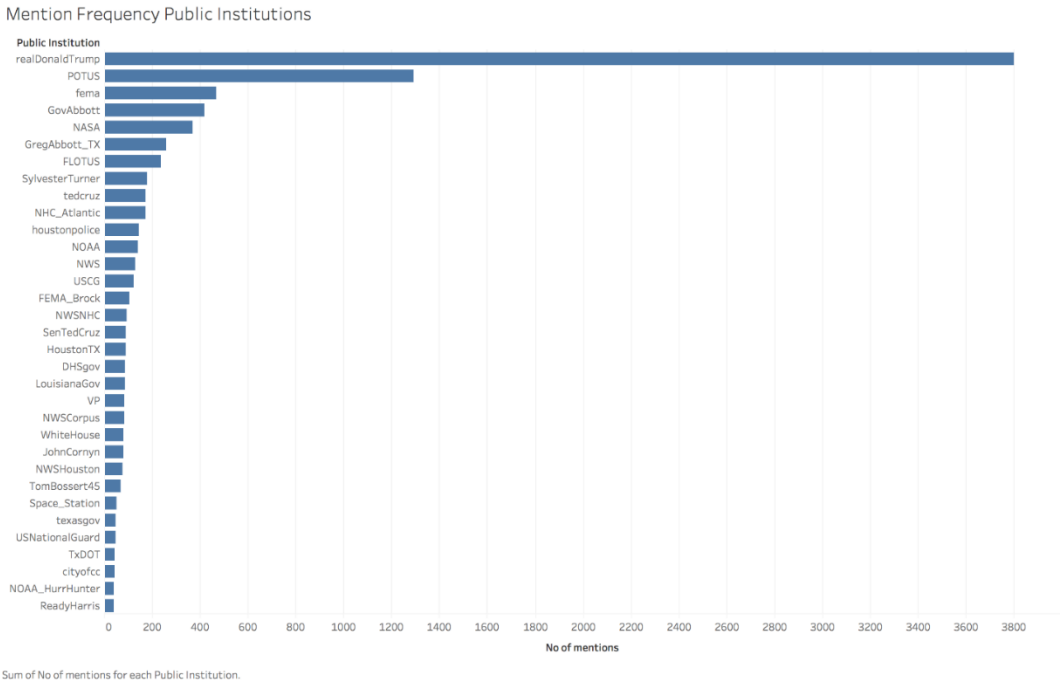
Data Appendices

	Documents	Twitter Data	
Jurisdictional Level	**Government Documents**	**Mentioned Public Institutions**	**Active Public Institutions**
Federal	Cooperation of all levels		
	Federal support according to the Stafford Act	President of the United States	
		First Lady of the United States	
		Vice President of the United States	
		The White House	
	U.S. Army Corps of Engineers		
	Federal Emergency Management Agency (FEMA)	Federal Emergency Management Agency	Strategic Planner of FEMA
		Administrator of FEMA	
		Senators for Texas	Senator of Texas
		Department of Homeland Security	
		National Weather Service	
		National Oceanic and Atmospheric Administration (US Department of Commerce)	
		National Aeronautics and Space Administration	
		U.S. Coast Guard	
		National Hurricane Center	National Hurricane Center
			Hazard Data Distribution System (USGS)
			US Consumer Product Safety Commission
			Coast Guard
			Chief of the National Guard Bureau
			Assistant Secretary for Preparedness and Response (ASPR)
			Texas State Representative TX 22
			Texas State Representative TX 137
State	Cooperation of all levels		
	Governor of the State must address all individuals and organizations	Governor of Texas	
		Governor of Louisiana	
			Public Utility Commission of Texas (Energy Conservation Campaign)
Regional	Cooperation of all levels		

	Harris County Flood Control District		
	Harris County Public Health Services		
	Harris County Sheriff's Office		Harris County Sheriff's Office
			Harris County Sheriff
		National Hurricane Center Atlantic Region	
			Lawrence County Emergency Management Director
			Alamo Area Council of Government
			Harris County Office of Homeland Security and Emergency Management (OHSEM)
Local	Lowest jurisdictional level	Major of Houston	
		City of Houston	
	Cooperation of all levels		
	Local Fire and Police Departments	Police Department of Houston	Firefighter Houston
		National Weather Service Houston	National Weather Service Houston
		National Weather Service Corpus Christi	National Weather Service Corpus Christi
			National Weather Service Brownsville
			National Weather Service San Antonio
			National Weather Service Shreveport
			Texas Department of Transportation San Antonio
			U.S. Coastguard Heartland

Appendix A: Public Institution accounts most mentioned and active sorted by their jurisdictional level



Appendix B: Mention Frequency Public Institutions

Agency/Public Institution	Account Name	Jurisdictional Level	No of Tweets
US Coastguard Heartland	USCGHeartland	Local	33
Lawrence County Emergency Management Director	LawrenceCOEM	Regional	29
NWSHouston	National Weather Service Houston	Local	13
NWSSanAntonio	National Weather Service San Antonio	Local	13
Member of Congress for TX-22	RepPeteOlson	State/Federal	24
Hazards Data Distribution System (USGS)	USGS_HDDS	Federal	23
National Hurricane Center	NHC_Atlantic	Federal	21
National Weather Service Corpus Christi	NWSCorpus	Local	21
US Consumer Product Safety Commission	USCPSC	Federal	14
Alamo Area Council of Governments	AlamoAreaCOG	Regional	15
Harris County Sheriff's Office	HCSOTexas	Federal	15
Harris County Sheriff	SheriffEd_HCSO	Federal	15

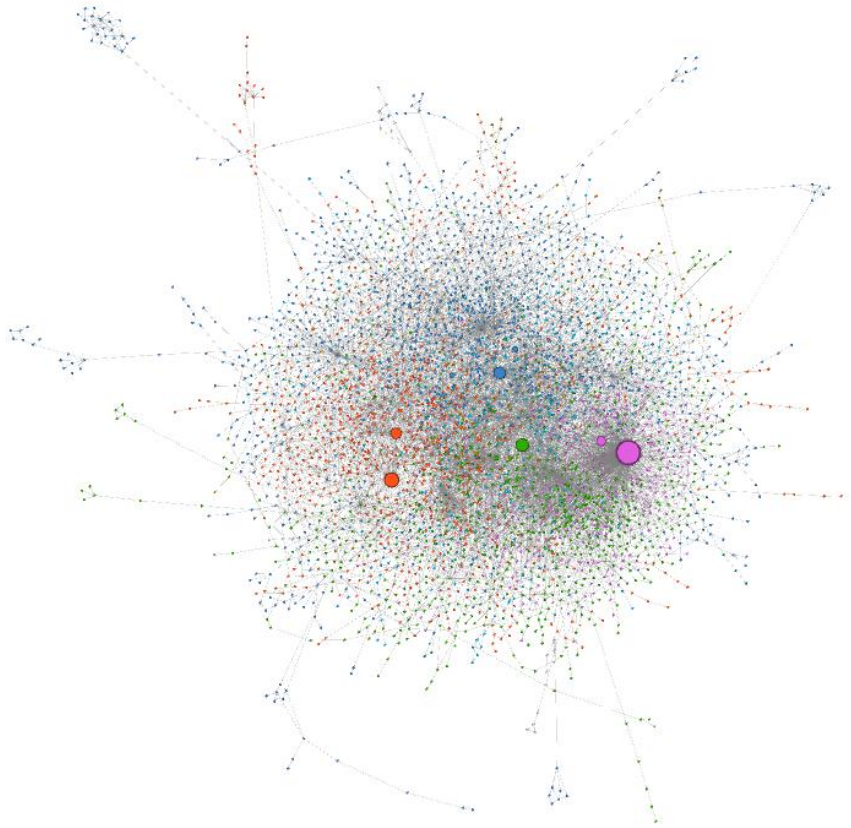
Texas Department of Transportation San Antonio	TxDOTSanAntonio	Local	14
Coast Guard Live	CGLiveApp	Federal	13
Chief of the National Guard Bureau	ChiefNGB	Federal	13
FEMA (Strategic Planner)	MichaelRLowry	Federal	13
National Weather Service Brownsville	NWSBrownsville	Local	12
National Weather Service Shreveport	NWSShreveport	Local	12
Public Utility Commission of Texas (Energy Conservation Campaign)	PowertoSaveTX	State	12
City of San Antonio	COSAGOV	Local	11
Firedepartment Houston (Firefighter)	DisasterPIO	Local	11
Harris County OHSEM	ReadyHarris	Regional	11
Senator of Texas	SenTedCruz	State	11
Texas State Representative (District 137)	GeneforTexas	State/Federal	10
Assistant Secretary for Preparedness and Response (ASPR)	PHEgov	Federal	16

Appendix C: Most Active Twitter Accounts of Public Institutions

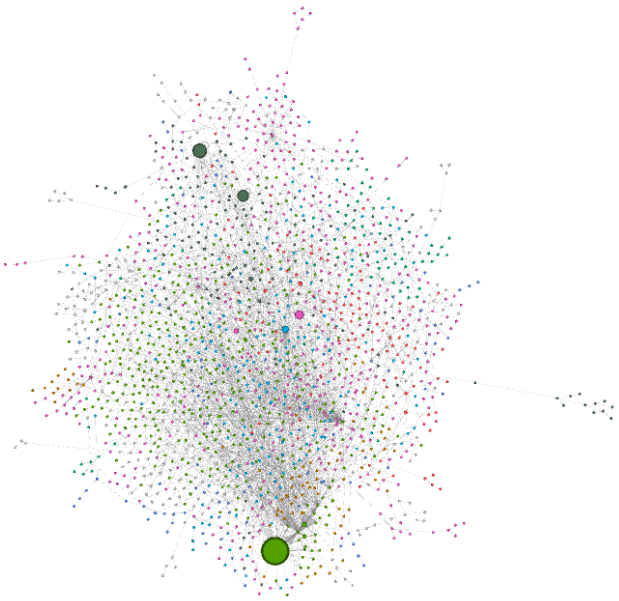
Public Institution	Account Name	Juridicitonal level	No of mentions
President of the United States	realDonaldTrump	Federal	3801
President of the United States	POTUS	Federal	1291
Federal Emergency Management Agency	fema	Federal	468
Governor of Texas	GovAbbott	State	419
National Aeronautics and Space Administration	NASA	Federal	367
Governor of Texas	GregAbbott_TX	State	256
First Lady of the US	FLOTUS	Federal	236
Major of Houston	SylvesterTurner	Local	180
Senator for Texas	tedcruz	Federal	173
National Hurricane Center Atlantic Region	NHC_Atlantic	Regional	171
Police Department Houston	houstonpolice	Local	142
Nationa Oceanic and Atmospheric Administration (US Department of Commerce)	NOAA	Federal	138
National Weather Service	NWS	Federal	129

U.S. Coast Guard	USCG	Federal	120
Federal Emergency Management Agency (Administrator)	FEMA_Brock	Federal	105
National Hurricane Center	NWSNHC	Federal	93
Senator for Texas	SenTedCruz	Federal	89
City of Houston	HoustonTX	Local	88
Department of Homeland Security	DHSgov	Federal	86
Governor of Louisiana	LouisianaGov	State	86
Vice President of the United States	VP	Federal	82
National Weather Service Corpus Christi	NWSCorpus	Local	81
The White House	WhiteHouse	Federal	80
Senator for Texas	JohnCornyn	Federal	77
National Weather Service Houston	NWSHouston	Local	76

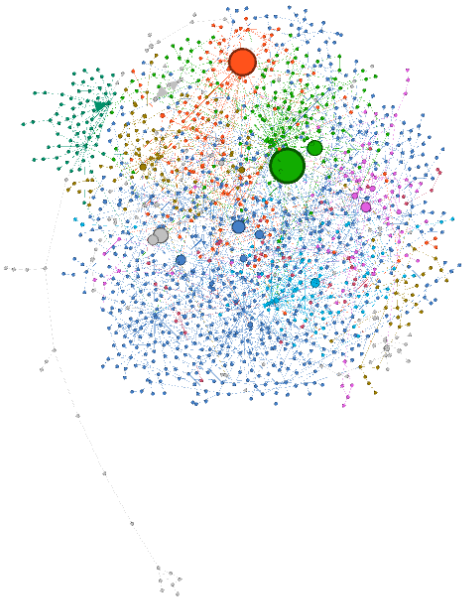
Appendix D: Most mentioned Twitter Accounts of Public Institutions



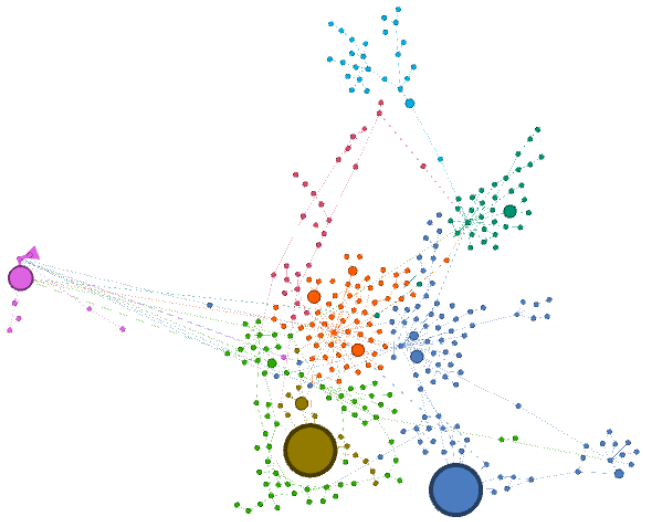
Appendix E: Social Network Analysis for the 25th of August 2017



Appendix F: Social Network of the 26th of August



Appendix G: Social Network for the 27th of August



Appendix H: Social Network for the 28th of August