

# Fostering Community Resilience through Adaptive Learning in a Social Media Age: Municipal Twitter Use in New Jersey following Hurricane Sandy

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result from the activities of central actors (i.e., government) and flow passively into the community. The emergence of social media is fundamentally changing the ways organizations and individuals collect and share information. Despite its growing acceptance, it remains to be determined how this shift in communication will ultimately affect community adaptive learning, and therefore, community resilience. This paper presents the initial results of a mixed-methods research effort that examined the use of Twitter in local municipalities from Monmouth County, NJ after Hurricane Sandy. Using a conceptual model of organizational learning, we examine the learning outcomes following the Hurricane Sandy experience.

## Keywords

Adaptive learning, disaster resilience, Hurricane Sandy, social media, Twitter.

## ABSTRACT

Adaptive learning capacity is a critical component of community resilience that describes the ability of a community to effectively gauge its vulnerability to the external environment and to make appropriate changes to its coping strategies. Traditionally, the relationship between government and community learning was framed within a deterministic paradigm. Learning outcomes were understood to

## INTRODUCTION

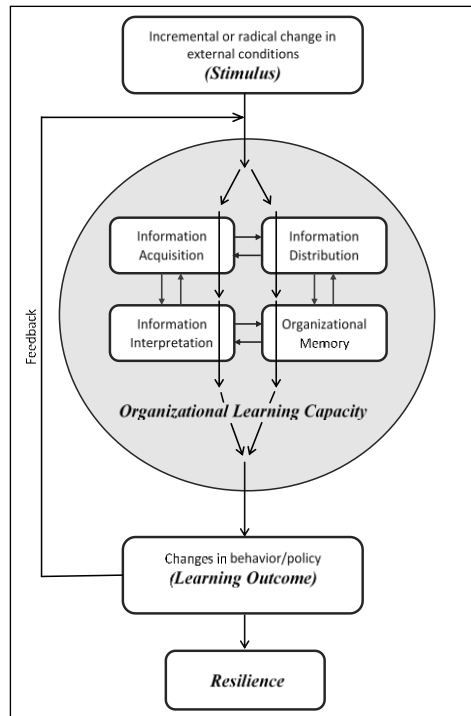
The impact of disasters worldwide has been growing significantly and the rate of this growth is unmanageable (UNISDR, 2013). The threats we face become less predictable, more complex, and more impactful (Berkes, 2007; Folke et al., 2010; Gallopín, 2006). Communities must learn how to adapt and find ways to become more resilient. The emergence of social media is fundamentally changing the

ways organizations and individuals collect and share information before, during, and after a disaster. It remains to be determined how this revolution in communication will ultimately affect community adaptive learning, and therefore, community resilience.

### COMMUNITY RESILIENCE AND ADAPTIVE LEARNING

The concept of resilience has a rich positivist tradition situated in ecology (e.g. Holling, 1973; Pimm, 1984). It originally referred to the amount of disturbance a system could endure while maintaining its essential function. Later, as the notion

of resilience was coupled with terms such as society or community, the conceptualization of resilience became more aligned with the constructivist epistemological approach. Recent resilience studies have devoted more attention to less obvious and more diffuse societal and human-based interactions, feedbacks, and processes (Carpenter et al., 2001; Folke, 2006; Gunderson 2000; Pendall et al., 2010). Based on this perspective, community resilience to natural disasters, or any other external change, has three pillars: 1) the amount of extrinsic force a community can sustain and still retain the same controls on structure and function; 2) the degree to which a community is capable of self-organization; and 3) the degree to which a community can build the



**Figure 1. Community Adaptive Learning**

capacity to learn and adapt.

Adaptive learning is a critical component of resilience that reflects the ability of a community to effectively gauge its vulnerability to the external environment and to make appropriate changes to its response, mitigation, and recovery strategies. While the literature on organizational learning is quite diverse, scholars generally agree that learning is a process through which organizations give meaning to information and adapt their behavior accordingly (Argyris & Schön, 1978; Levitt and March, 1988; Miller, 1996; Weick, 2001). Generally speaking, learning contains four constructs: information acquisition, information interpretation, information distribution, and organizational memory (Huber, 1991) (Figure 1). Information acquisition refers to the timing, quality, and quantity of new information that an organization obtains when an external environmental change is present. Information distribution refers to the network and mechanism that an organization employs to gather, verify, and disseminate this information. Information interpretation refers to the sense-making process that an organization takes to analyze the information, and then to formulate and prioritize action items. Organizational memory refers to the organizational transformation achieved as a result of this information processing. This can include a new set of behavior protocols, policy documents, or specific changes to organizational structure (Walsh and Ungson, 1991).

### SOCIAL MEDIA AND THE NEW LEARNING PARADIGM

Scholarly research on the capacity for adaptive learning in the face of hazards continues to evolve. Traditionally, the relationship between government and community learning was framed within a deterministic paradigm. Learning outcomes were understood to result from the activities of central actors (i.e., government) and flow passively into the community. Critics have argued that because organizations are bound by cognitive, resource, political, and ideological structures, they become stagnant in their routines and beliefs and thus limited in their capacity for learning (e.g. Argyris & Schön, 1978; Miller, 1996; Weick, 2001). Consequentially, their learning outcomes are likely subject to insufficient information acquisition, insufficient information distribution, biased information interpretation, and inappropriate organizational memory.

The emergence of social media has helped shift learning towards a participatory paradigm. The static, one-way information flow of traditional communication has transformed into dynamic, collaborative information generation and sharing during disasters and otherwise. Recent research has noted cases where social media was a primary communication venue for affected individuals both during and after a disaster event (Hiltz et al., 2014; Hughes et al., 2014; Palen et al., 2010). In several recent emergencies, social media platforms have emerged as the most reliable, and sometimes the only available form of communication (e.g. Acar et al., 2001; Peary et al., 2012; Kiago, 2012; Vieweg, 2012).

## RESEARCH HYPOTHESIS AND RATIONALE

In the social media age, individual citizens have a degree of autonomy over communication that previously was not available to them. We expect this participatory nature of social media to transform community learning capacity by enhancing all four key components of the organizational learning cycle -- information acquisition, information distribution, information interpretation, and formulation of organizational memory (Kim & Khang, 2014). As a consequence, we also expect social media to increase communities' resilience to the growing threat of hazards.

## METHODOLOGY

We studied the usage of Twitter in New Jersey coastal communities that were heavily affected by Superstorm Sandy in 2012. The magnitude of the storm and the unfamiliar challenges overwhelmed the formal response and recovery capabilities of many impacted communities. We focused specifically on Monmouth County, NJ (Figure 2).

The authors collected two forms of Twitter data. We interviewed eight officials from seven municipalities within Monmouth County in September 2014 about their experiences with social media after Sandy. Interview subjects included mayors, emergency management coordinators, and public information officers who were serving in official government roles during the storm. We designed the semi-structured interview protocol according to the community adaptive learning

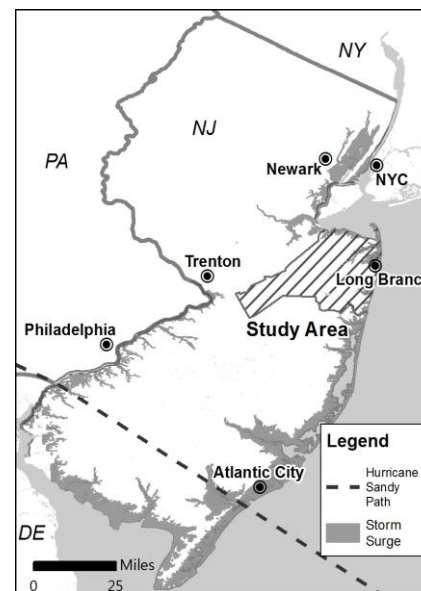


Figure 2. Study Area in New Jersey

framework (Figure 1). The goal of these interviews was to gather qualitative information about social media's contribution to information acquisition, information distribution, information interpretation, and organizational memory. In addition to the interviews, we purchased tweets from GNIP that originated from the study area for three time periods: one week before to one month after the storm, the sixth month after the storm, and the thirteenth month after the storm. We collected a total of 1.52 million tweets. After applying filters suggested by the literature (Hughes et al. 2014, Saffer, 2012) to extract tweets related to preparedness, response, and recovery following Superstorm Sandy, the final count of valid tweets was 8,653. From the filtered tweets, we extracted official twitter accounts that belong to local government or non-government agencies that have roles in disaster management. We then identified preliminary quantitative indicators to measure the communication network between public twitter accounts and official twitter accounts, according to the aforementioned organizational adaptive learning framework.

We generated two indicators to quantify *information acquisition* by an organization via Twitter: 1) the number of replies to tweets originated from an organization's twitter account and; 2) the number of direct tweets (i.e. @ mentions) sent to an organization's Twitter account. Higher relative values of these two indicators would suggest that residents used Twitter to send information to local organizations. We generated two indicators to measure *information distribution*: 1) the number of direct tweets made by an official Twitter account

and; 2) the in-degree centrality of an official Twitter account, which refers to the number of times tweets originated from an account were retweeted. These two indicators measure the extent to which twitter was used by local officials to distribute information. We considered two indicators for *information interpretation*: 1) the number of replies made by an official Twitter account to direct tweets it received; and 2) out-degree centrality of an official Twitter account, which refers to the number of times this particular official Twitter account retweeted others' tweets. In these two measures, we assumed that when an official took the time to reply or retweet a message, it indicates that this particular message had been processed (interpreted) by the local official.

## RESULTS

Because of the length constraint, we only report results of tweets analysis for six selected official Twitter accounts for the period from one week leading up to the storm and one month following the storm. A full report with the additional time periods will be provided in future papers. The six selected official Twitter accounts include a federal agency account (FEMARegion6), an official state account (GovChristie), and three local official accounts.

### Information Acquisition

Most interview respondents utilized traditional sources of communication and were primarily concerned with weather forecasts and conditions related to situational awareness during the preparedness and response period. Information was largely passed down from state and federal sources to the county OEM, where it was distributed to the municipalities. Respondents explained that limited social media usage at this stage was due to the fact that staff, resources, and first responders were doing all they could to stay on top of the more traditional forms of communication. Whether or not local officials had the capability or intention of utilizing social media, it was a common theme among respondents that social media information acquisition was not a priority in the immediacy of the storm.

Social media did play a role in information acquisition during the recovery phase. In one notable example, a mayor described a successful effort of putting out a request on Twitter for residents to submit recent time-stamped pictures they had

taken of the local roads, in order for the local government to prove they had man-hole covers in place before Sandy in order to receive federal funds for sewer repairs.

Tweets analysis (Table 1 and Table 2) concurs with the interviews. While residents in Monmouth County used Twitter to provide information to official accounts, both in the form of direct messages and in the form of replying to tweets sent by official accounts, Twitter usage for information acquisition was low and uneven. Governor Christie received the most direct messages (3) and replies (4). Very few persons sent tweets to the FEMA Region 2 account and the accounts of local officials.

Date	Belmar Mayor	FEMA Region2	Gov Christie	Manasquan OEM	Seabright Mayor
11/1/12			1		
11/3/12				1	
11/5/12			1		
11/11/12			1		
Total			3	1	

**Table 1. Information acquisition: number of replies to selected official twitter accounts after Sandy**

Date	Belmar Mayor	FEMA Region2	Gov Christie	Manasquan OEM	Seabright Mayor
10/28/12			1		
10/29/12		1			
10/31/12			1		
11/5/12			1		
11/19/12			1		
Total		1	4		

**Table 2. Information acquisition: number of direct message to selected official twitter accounts**

### Information Distribution

The interviewees indicated that protocol or policy changes had been made to clarify the chain of command for social media content creation and consistency. Six out of the eight respondents discussed the importance of distributing a consistent message across their social media and traditional communication platforms. Respondents also emphasized the importance of having a designated person or team in charge of managing the accounts. Though most respondents praised social media for its rapid conveyance of information and the ability to coordinate decentralized actors, several interviewees noted this need for message consistency creates an opposing force that pulls social media users away from decentralization and back towards bureaucracy. The balance between rapid information flow and organizational information control was something several municipal leaders mentioned when reflecting on their experience with Hurricane Sandy.

Tweets analysis shows that some local officials used Twitter to disseminate original information (Table 3). But the numbers are small and uneven across three local twitter accounts. The in-degree centrality measures for each official account have relatively bigger numbers (Table 4), suggesting that tweets originating from official accounts were received, processed and retweeted by residents in the area. Governor Christie's tweets were retweeted 24 times. All three local accounts also had their tweets retweeted, though the number of incidents were small.

Date	Belmar Mayor	FEMA Region2	Gov Christie	Manasquan OEM	Seabright Mayor
10/27/12					1
10/28/12					2
10/29/12					2
10/30/12				1	
10/31/12				3	
11/7/12					1
11/8/12					1
Total				4	7

**Table 3. Information distribution: number of direct tweets made by selected official twitter accounts**

Date	Belmar Mayor	FEMA Region2	Gov Christie	Manasquan OEM	Seabright Mayor
10/28/12			1		
10/31/12			5		
11/1/12	1	2	2		
11/2/12			1		
11/3/12	1		3	1	
11/4/12			1	1	
11/5/12				1	
11/7/12			3	1	1
11/8/12			3		
11/13/12			2		
Total	2	2	21	4	1

**Table 4. Information distribution: in-degree centrality**

### Information Interpretation

Amongst our interview sample, social media was predominately used as a 1-way content delivery tool. For the most part, respondents indicated that social media was not an information source they monitored for useful sense-making activities. They would only informally monitor information from citizens that was coming in through social media, in order to keep aware of issues, but that this was not a formal practice. The primary reason given for keeping social media monitoring informal was a lack of staff support. With rare exceptions, many local officials are part-time workers or volunteers and they do not have the resources to guarantee timely monitoring of social media.

Tweets analysis is consistent with the interviews (Table 5, Table 6). Other than the Mayor of Sea Bright who actively replied to tweets sent to her account and retweeted information related to disaster response and preparedness, none of the local official Twitter accounts we studied engaged in replying and retweeting activities.

Date	Belmar Mayor	FEMA Region2	Gov Christie	Manasquan OEM	Seabright Mayor
10/28/12					1
11/4/12					1
11/6/12					3
Total					5

**Table 5. Information interpretation: number of replies made by selected official twitter accounts**

Date	Belmar Mayor	FEMA Region2	Gov Christie	Manasquan OEM	Seabright Mayor
10/29/12					4
10/30/12					1
11/1/12					1
11/3/12					2
11/13/12					1
11/26/12					1
11/29/12					1
Total					11

**Table 6. Information interpretation: out-degree centrality**

### Organizational Memory

None of the respondents had made any effort to actively archive or review the social media data they had collected. Several were concerned about the privacy and record keeping requirements if they were to take such action. There was no indication that saving or analyzing social media data was a priority.

Seven of the eight respondents indicated that because of their experience with Sandy or Hurricane Irene from the previous year, they had taken steps or planned to take steps to update or create a social media policy document. For some, this was nothing more than acceptable use guidelines for staff, but for others, it was a broader policy that was being incorporated into their emergency management plan. From our conceptual model of organizational learning, such an action would represent an attempt to build organizational memory by transcribing experiential knowledge into best practice policy. The role staff plays within social media practice varied with the size of government. While larger municipalities might have full-time information officers, respondents in our study indicated that the division of social media responsibility was less formal and often times split between the small staff.

## LIMITATIONS

We acknowledge several limitations to this research, mainly concerning the approach we used for data collection and tweets analysis. First, we collected tweets data that were geo-tagged to the study area. Most geo-tagged tweets originated from mobile devices. This could have greatly limited the number of tweets sent by government Twitter accounts in our sample. In addition, our data collection approach excluded official Twitter activities (e.g. @GovChristie) that took place outside of our study area. These two factors together help to explain the unusually small values we observed across the indicators for official Twitter accounts. Second, our preliminary quantification of the four components of organizational learning capacity would greatly benefit from content analysis of tweet conversation between citizens and the officials at all governmental levels. Content analysis will not only allow us to contextualize the quantitative indicators, but to also extract topical themes that emerged during the conversation. Such results would enrich our understanding of the effect social media has on community adaptive learning.

## CONCLUSION

We examined the effect Twitter has on the four components of community learning capacity -- information acquisition, interpretation, dissemination, and organizational memory. Our preliminary findings suggested that while social media is increasingly recognized as a promising communication tool, its impact on the adaptive learning capacity of local communities is minimal. Social media remains a novel technology that generates a lot of interest among governmental agencies and residents, but our analysis found marginal evidence of capacity building across all components of the organizational learning cycle. These findings concur with some of the existing literature (e.g. Hughes et al. 2014).

On a positive note, local communities have started to make efforts to institutionalize social media usage. Protocols or policy changes are taking place to clarify the management structure for social media data creation, dissemination, quality control, and its coordination with traditional communication platforms. Local officials also realize the importance of having a designated person or team

in charge of managing social media. While the actual usage of Twitter in our study was minimal and uneven across different localities and different accounts, we did find evidence that social media in some instances served as a communication tool for either gathering, distributing, or processing information.

Nevertheless, social media as an adaptive learning tool for local communities faces several obstacles. The first one has to do with the nature of disaster response in the United States. During large scale disasters, resources primarily come from the federal and state governments and resource distribution is heavily regulated by pertaining federal and state policies. For the most part, localities are at the receiving end of information and only have limited roles at this stage of disaster management. Second, as noted by previous research (e.g. Hiltz et al. 2014), the usage of social media in local communities is greatly hindered by lack of staff support and resources. As a consequence, social media is mostly treated as a side project, rather than as a formal institutional activity. More importantly, the lack of resources means that social media is not an information source that is being constantly monitored and utilized. Past archives of social media data are unlikely to be examined systematically to inform future policies and activities. Third, social media's power relies on its rapid conveyance of information and its ability to connect decentralized actors. However, from the perspective of government officials we spoke with, the best way to make social media more user-friendly for them, especially in a disaster setting, is to assert structure and bureaucracy on social media technology and users. This inherent conflict means that new technology for structured, action-oriented data mining is needed for effective usage of social media by communities.

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## REFERENCES

1. Acar, A. & Muraki, Y. (2011). Twitter for crisis communication: lessons learned from Japan's tsunami disaster. *International Journal of Web Based Communities*, 7(3), 392-402.
2. Ahlqvist, T., Bäck, A., Halonen, M., & Heinonen, S. (2008). Social media roadmaps: exploring the futures triggered by social media. *VTT Tiedotteita – Research Notes* 2454.
3. Argyris, C. and Schön, D. (1978). *Organizational learning: a theory of action perspective*. Reading, MA, Addison-Wesley.
4. Berkes, F. (2007). Understanding uncertainty and reducing vulnerability: lessons from resilience thinking. *Natural Hazards*, 41(2), 283-295.
5. Carpenter, S., et al. (2001). From metaphor to measurement: resilience of what to what? *Ecosystems*, 4(8), 765-781.
6. FEMA (2013). *Hurricane Sandy After-Action Report*. Washington D.C.: FEMA.
7. Folke, C. (2006). Resilience: the emergence of a perspective for social–ecological systems analyses. *Global Environmental Change*, 16(3), 253-267.
8. Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society*, 15(4), 20-29.
9. Gallopín, G. C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change*, 16(3), 293-303.
10. Gunderson, L. (2000). Ecological resilience – in theory and application. *Annual Review of Ecology, Evolution, and Systematics*, 31, 425-439.
11. Hiltz, S. R., et al. (2014). Use of Social Media by U.S. Public Sector Emergency Managers: Barriers and Wish Lists. *11th International ISCRAM Conference Proceedings*, University Park, Pa: 602-611.
12. Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology, Evolution, and Systematics*, 4, 1-23.
13. Huber, G. (1991). Organizational learning: the contributing processes and the literatures. *Organization Science*, 2(1), 88-115.
14. Hughes, A. L., et al. (2014). Online public communications by police & fire services during the 2012 Hurricane Sandy. *ACM 2014 Conference on Human Factors in Computing Systems*. Toronto: 1505-1514.
15. Kaigo, M. (2012). Social media usage during disasters and social capital: twitter and the great east Japan earthquake. *Keio Communication Review*, 34, 19-35.
16. Kim, Y. and Khang, H. (2014) Revisiting civic voluntarism predictors of college students' political participation in the context of social media. *Computers in Human Behavior*, 36, 114-121.
17. Levitt, B. and March, G. (1988). Organizational learning. *Annual Review of Sociology*, 14, 319-340.
18. Miller, D. (1996). A preliminary typology of organizational learning: synthesizing the literature. *Journal of Management*, 22(3), 485-505.
19. Palen, L., et al. (2010). A Vision for Technology-Mediated Support for Public Participation & Assistance in Mass Emergencies and Disasters. *Association of Computing Machinery and British Computing Society's 2010 Conference on Visions of Computer Science*.
20. Peary, B., Shaw, R., & Takeuchi, Y. (2012). Utilization of social media in the east Japan earthquake and tsunami and its effectiveness. *Journal of Natural Disaster Science*, 34(1), 3-18.
21. Pendall, R., Foster, K. A., & Cowell, M. (2010). Resilience and regions: building understanding of the metaphor. *Cambridge Journal of Regions, Economy and Society*, 3(1), 71-84.
22. Pimm, S. (1984). The complexity and stability of ecosystems. *Nature*, 307(26), 321-326.
23. Saffer, M. (2012). #HurricaneSandy: How Twitter & Hashtags Helped New Jersey. *PCG Digital Marketing*. Available at: <http://www.pcgdigitalmarketing.com/2012/11/20-how-twitter-helped-new-jersey-during-sandy/>. Retrieve at: Dec.5th, 2014.
24. UN-ISDR (2013). *Global Assessment Report on Disaster Risk Reduction*:



*From Shared Risk to Shared Value*. New York: The United Nations.

25. Vieweg, S. E. (2012). Situational awareness in mass emergency: a behavioral and linguistic analysis of microblogged communication. Alliance for Teaching, Learning, and Society. University of Colorado. Doctor of Philosophy: Teaching, Media, and Society: 300.
26. Walsh, J. and Ungson, G.R. (1991). Organizational memory. *Academy of Management Review*, 16(1), 57-91.
27. Weick, K. E. (2001). *Making sense of the organization*. Malden, MA, Blackwell Publishing.