

Building Coordination Capacity: Post-Disaster Organizational Twitter Networks

Analysis of Organizational Twitter Use Following Super Typhoon Haiyan in the Philippines

Aaron Opdyke and Amy Javernick-Will

Department of Civil, Architectural, and Environmental Engineering
University of Colorado Boulder
Boulder, Colorado USA
aaron.opdyke@colorado.edu; amy.javernick@colorado.edu

Abstract— Effective coordination is essential for post-disaster reconstruction. Presently, however, there are relatively few tools to help organizations manage coordination and communication of post-disaster construction activities. Given the recent increase in use of social media platforms, we examine the use of Twitter following Super Typhoon Haiyan (Yolanda) in the Philippines. A network of organizations in the infrastructure sector is created to capture the coordination structure, as depicted through social media, analyze organizational messaging and determine key actors. A content analysis of tweets further examined emergent themes in the distribution of information through Twitter. This network perspective lends insight into future applications of how organizations can leverage social media as a means of sustained coordination for long-term, on the ground efforts extending past initial emergency relief phases.

Keywords—Coordination; Twitter; Disasters

I. INTRODUCTION

Post-disaster environments place enormous stress on reconstruction organizations, demanding high quality results in the most difficult of scenarios. Even basic operations are impeded by human and material resourcing challenges, psychological obstacles, and budgetary constraints. To compound these functions, reconstruction activities are highly interrelated, requiring that organizations plan and design projects to account for the actions of other parties. Post-disaster housing is a classic archetype – it requires integrating a building structure with electrical services, potable water, sanitation facilities, and transportation. To navigate this complexity, organizations must employ coordination processes that manage the dependencies between activities [1].

Practitioners and academics alike cite that coordination among organizations is essential in the rebuilding process [2]; however, relatively few concrete tools and strategies have been proposed. As a result, coordination is an elusive task that has resulted in poorly managed projects in almost every major disaster ranging from duplication of services to performance inefficiency. The cluster system, established by the United Nations through the Inter-Agency Standing Committee (IASC) in 2005, is one such mechanism that was created to address coordination in disaster response and recovery. It currently includes nine sectors: nutrition, health, water/sanitation,

emergency shelter, camp coordination/management, protection, early recovery, logistics, and emergency telecommunications [3]. The system has been criticized for its separation of services in recent years, but in practice it may not be the structure, rather the processes used for coordination where the system could be enhanced. Much of the current system makes use of in-person cluster meetings and basic web-based information sharing. Further, coordination systems rapidly dissipate when clusters are closed, often within a year of major disasters, leaving a need for alternative solutions for sustaining coordination efforts as agencies and organizations continue recovery activities. Information and communication technology solutions pose strong potential to address deficiency gaps in the current system and could transition coordination mechanisms to virtual interaction to save time and cost. In this paper we examine Twitter usage by organizations following Super Typhoon Haiyan (Yolanda) in the Philippines to understand how one social media platform, Twitter, can be used as a virtual coordination mechanism. We ask: *What role can social media platforms, such as Twitter, play as a coordination mechanism for long-term post-disaster construction?* In contrast to previous studies of Twitter, which have focused on immediate, short-term response, this research focused on the use of Twitter to coordinate permanent construction projects. As time after a disaster increases, coordination outlets typically see decreased participation; through this paper we investigate potential in social media, such as Twitter, to bolster long-term information exchange in the disaster context. In answering the above question, we will not only address patterns in long-term use of Twitter but also present recommendations to achieve intra-sector and inter-sector coordination.

II. POINTS OF DEPARTURE

A. Coordination

Early work on disaster recovery sought to characterize the process as predictable; recent work has shown that the realities of rebuilding make it a dynamic, complex series of events [4]. Following a disaster, services evolve from meeting immediate needs to rehabilitation and permanent solutions. While still high pressure, the levels of uncertainty and decision-making speed that characterize rapid response are reduced for

permanent construction [5]. For organizations that focus on permanent construction in the years after an event, the organizational dynamics are significantly different than emergency services and require different information management systems. Understudied, coordination for these projects relies on sustained communication. The importance of coordination in this environment is no less significant, however we must adopt different principles that guide long-term coordination efforts, knowledge of which has received little attention to date. Researchers have documented that coordination improves the recovery process [6], but there remain gaps about processes and systems that can go about building this capacity as well as knowledge about how coordination actually unfolds.

B. Twitter Use Following Disasters

Twitter and other social media platforms have been hailed for their ability to connect individuals following disaster events, promoting emergent virtual communities of responders. A signal of this shift is the growing interest from established agencies and organizations. Following individuals' actions, organizations are quickly adopting social media as an outlet to share information in disaster contexts as mobile and internet coverage expand around the world. Previously, information flows could take days or even weeks to filter through traditional media outlets. This increase in adoption has been especially true for disasters in developing countries where existing communication challenges are compounded by disaster effects. The rise of virtual platforms is new in that organizations, from headquarter staff to on the ground personnel, have access to instant information. In particular, Twitter has risen to the top as one of the more popular choices for organizations and their staff working in disaster response. Its simplicity and flexibility have made it an excellent means of sharing and tracking information.

Having only started in 2006, Twitter use has grown exponentially. Several recent disasters such as 2010 Haiti earthquake, the 2011 Tohoku earthquake and tsunami, and more recently Super Typhoon Haiyan, have all seen Twitter deployed by organizations and citizens alike. With each disaster, further knowledge emerges as to how Twitter is playing a vital role and can continue to improve communication. As researchers have highlighted [7], it is well-suited to disaster applications due to its adaptive nature. This flexibility is essential not only for short-term response, but also long-term recovery. Tweets have been analyzed for public perception [8], government applications [9], and sensor data [10]. These studies have focused on a narrow range of dates, however, and there has been little attention paid to the sustained communication potential of Twitter. From the onset of research in Twitter use in disasters, questions were raised about the validity of self-reported information. Work has examined this closely and found that a high percentage of tweets are credible with relatively small numbers of inaccurate posts [11]. The recent work in this area is one reason for its adoption by agencies and governments as a recognized means of legitimate communication and information.

Because organizational and individual use of Twitter differ, and much of the work to date has been based upon individual

usage [12]–[15], there is a need for additional study that focuses on organizational use of Twitter. Previous examination of twitter content shows that situation awareness is one of the largest bodies of tweets that originate from disasters [16]. This is especially true for organizations that use social media as a means to reach the global community. Foremost, public distribution of messaging demonstrates commitment on behalf of an organization [17]. It also serves to connect organizations with their constituents through a messaging style that is conversational versus formal in nature.

In organizational use of Twitter, existing work has maintained a limited focus on how a single entity, or small numbers, are using Twitter. This has been driven by the limited number of organizations actually using Twitter in disasters until recently. For example, Twitter was used in Indonesia as an early tsunami warning system [18]. In this case, messaging originated from a formal entity – the Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG), but a robust network of organizations did not exist. As emerging trends see more organizations adopt Twitter use, this pool of organizations has created new dynamics. The study of networks where multiple organizations are generating and controlling information is inherently more complex but there are also significant benefits from harnessing this potential. Twitter presents a unique mechanism because of its strong social foundation – a perspective that is often ignored in theoretical stances on coordination, but has emerged from increased social media presence in disasters [19]. The use of Twitter by organizations is expanding rapidly and models have been proposed to integrate tweets into a formal structure for response coordination [20], however little work exists on how these organizations are currently using it for long-term disaster communication. We address this gap by analyzing a case of its use to understand where communication gaps still remain.

III. SUPER TYPHOON HAIYAN (YOLANDA)

Home to more than 96 million people, the Philippines ranks as the 12th most populous country in the world [21]. Composed of more than 7,000 islands, the country is scattered across a landmass that encompasses 299,404 square kilometers (115,601 square miles). Historically, the Philippines has been one of the most hazard prone countries in the world. Its low elevations, vast coastline, and socioeconomic inequalities pose complex development challenges. In the last ten years alone the country has seen an average of nearly nineteen disasters annually, causing devastating loss of life and damage. A summary of these disasters is presented in Table 1. In the recent UN World Risk Report, the Philippines ranked third globally, only behind Vanuatu and Tonga – a dangerous combination of high exposure and prevalent vulnerabilities [22]. Its infrastructure systems are in need of upgrade in order to handle increasing impacts from climate change and policy transformation is required to equip institutions with the ability to make progress towards national disaster risk reduction goals. Filipinos remain resilient despite the aforementioned shortcomings and progress is underway. The large occurrence of disasters has created a strong disaster awareness culture for the population that has driven increased allocation of government resources to combat natural hazards.

TABLE I. SUMMARY OF DISASTERS IN THE PHILIPPINES

Year	Number of Disasters	Number Killed	Number Injured	Number Affected	Total Damage (US\$ Millions)
2004	13	1,950	1,321	3,253,055	\$3,253
2005	4	39	0	213,057	\$213
2006	20	2,984	2,703	8,610,114	\$8,610
2007	16	129	24	2,023,068	\$2,023
2008	20	959	1,015	8,404,236	\$8,404
2009	25	1,307	900	13,351,474	\$13,351
2010	15	1,113	124,096	5,457,411	\$5,457
2011	36	1,989	6,703	11,723,244	\$11,723
2012	22	2,415	2,879	12,492,805	\$12,492
2013	14	8,382	29,830	25,637,240	\$25,637
Average	18.5	2,127	16,947	9,116,570	\$9,117
Standard Deviation	8.5	2,390	38,704	7,357,424	\$7,357

Source: [23]

In November of 2013 Super Typhoon Haiyan, locally known as Yolanda, slammed into the Visayas region of the Philippines. Making landfall in the province of Eastern Samar, the storm sustained wind speeds of 315 kilometers per hour (196 mph) with gusts up to 380 kilometers per hour (235 mph) – the strongest storm to ever make landfall and the fourth most intense recorded [24]. In its wake, the storm killed 6,201 people, injured another 28,626 others and impacted more than 16 million individuals [25]. Infrastructure was severely damaged in multiple sectors. Over four million people were displaced from their homes and more than 1.1 million homes were damaged, half of these completely destroyed. The islands of Leyte and Samar sustained the most damage – Tacloban City, Leyte’s largest urban center, reported ninety percent of infrastructure destroyed [26]. An abundance of organizations arrived in its wake, many learning from previous experiences after the 2010 Haiti earthquake and from the 2004 Indian Ocean Tsunami. Recognized from these lessons, coordination was a high priority for many organizations. More than six months after Haiyan, these entities reported that desired levels of coordination were still not being achieved, not for lack of effort, but rather a result of the absence of accessible information exchange tools.

Aside from natural hazards, the Philippines tops the charts in another, but completely different, category – social media usage. Paired with growing trends for Twitter use by non-governmental organizations (NGOs) and governments, there was a strong virtual response to Super Typhoon Haiyan. This combination has posited the Philippines as an ideal case to study organizational Twitter use and implications for future coordination.

IV. METHODOLOGY

In order to assess the use of twitter as a coordination mechanism following Super Typhoon Haiyan, we first identified a representative sample of organizations working in the disaster field. An initial pool of organizations was selected

from Interaction, a US-based consortium of over 170 organizations that work in disaster management, response, and recovery. United Nations entities as well as known organizations that responded to Haiyan were also included. In total, over 200 organizations were identified for study. From these, 172 organizations had twitter accounts from which a complete history of posted tweets was collected through April 8, 2014 (5 months after Haiyan made landfall). Five months was chosen as it saw the first reports of early reconstruction and rehabilitation, transitioning away from emergency services. This differs significantly from other studies that have examined Twitter as these studies typically focus on short periods after a disaster. The collected database included 345,382 tweets, of which 279,603 were original tweets posted by the selected organizations and the remaining were retweeted posts. Data was filtered for tweets that contained any combination of the keywords ‘Philippines,’ ‘Yolanda,’ or ‘Haiyan’ and tweets prior to the disaster, as well as retweets, were discarded. While a case could be made that retweets have equal potential as a coordination mechanism, this study honed on information that originated from an organization. A second tier of keyword searches was completed to separate content into infrastructure sectors as follows: WASH, shelter, power, transportation, education, and health. From a construction standpoint, these sectors present more concise divisions for long-term reconstruction over the UN defined clusters, many of which dissolve or lose relevancy in long-term rebuilding and rehabilitation. This is not to discount the function of other activities, such as economic and livelihoods development, but this analysis targets the built environment as its coordination needs differ. Keywords used for each sector are listed in Table 2. The search also included words that stemmed from keywords listed.

We examined mentions as a means of gauging formal communication and acknowledgment between two entities. In analyzing formal communication, we use network analysis to better understand organizational connections. This is examined further through a content analysis of tweets to build trends that

resulted within each sector. Combining these two methods allows for a structural view of the residing international network of responders while also providing useful information on themes in their composition. The unique combination of qualitative and quantitative methods are complimentary and add depth and validity to the findings.

TABLE II. SECTOR KEYWORDS

Sector	Keywords
WASH	WASH, water, hygiene, sanitation
shelter	shelter, home, housing, house
power	power, electricity
transportation	transport, road
education	education, school, classroom
health	health, hospital, clinic

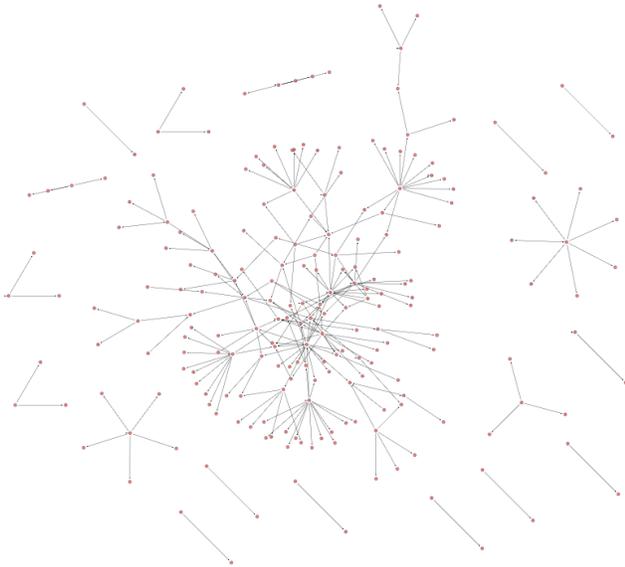


Fig. 1. Multi-Sector Organization Network

V. RESULTS

A. Network Analysis

A structural network was initially constructed to analyze and visualize inter-organizational connections from filtered tweets. Six sub-networks were constructed, one for each sector, as well as a cumulative network with all of the sectors together. The overall network consisted of 212 users, suggesting that a relatively small number of mentions occurred outside of the sampled organizations. This is promising to support that the sample of organizations selected is representative of organizational Twitter use following Haiyan.

As can be seen from Figure 1, one of the most apparent findings is that approximately one-third of organizations were distanced from the main network. This can be visualized from the small clustering of nodes that are separated from the primary network. These isolated users have important implications when considering coordination; they are not included in mentions from others and they do not mention the

primary network users. These organizations may access information distributed from other parties, however mentions act as a means of verifying that information is transmitted. Many organizations are well connected however and there is a central hub of active organizations where reciprocity between users is common. Additional use and connectivity by the external users would enhance information flows. Both the centralized organizations and peripheral play a role in creating a coordination network that enables dissemination of information to the needed parties.

TABLE III. TOP 5 USERS BY SECTOR

	User	In-Degree	User	Out-Degree
WASH	washingtonpost	0.033	OxfamAmerica	0.038
	UNICEF	0.019	theOFDA	0.024
	theOFDA	0.009	PlanPhilippines	0.014
	PlanGlobal	0.009	reliefweb	0.014
	UNOCHA	0.009	PlanUSA	0.014
Shelter	ShelterCluster	0.028	IOM_Philippines	0.076
	UNPhilippines	0.019	HelpAge_USA	0.062
	UNHABITAT	0.014	CAREphl	0.052
	ValerieAmos	0.014	BuildChangeNews	0.043
	UNDP	0.014	theOFDA	0.028
Power	WFP	0.014	Concern	0.019
	nancylindborg	0.009	theOFDA	0.014
	theOFDA	0.005	PlanPhilippines	0.009
	DFID_UK	0.005	Heart_to_Heart	0.009
	CarinAtPlan	0.005	USAID_Manila	0.009
Transportation	UNICEF	0.009	IOM_Philippines	0.028
	UNDPPH	0.005	PlanPhilippines	0.014
	irinnews	0.005	UNOCHA	0.014
	CarinAtPlan	0.005	ReliefIntl	0.009
	maria_ressa	0.005	UNDP	0.005
Education	UNICEF	0.009	IOM_Philippines	0.019
	UNDPPH	0.005	unicefphils	0.014
	CarinAtPlan	0.005	PlanPhilippines	0.014
	eu_echo	0.005	BuildChangeNews	0.014
	unisdrr	0.005	UNDP	0.005
Health	irinnews	0.009	AmeriCares	0.062
	WHO	0.009	DirectRelief	0.019
	UNFPA	0.005	Physician4Peace	0.014
	SavetheChildren	0.005	PlanPhilippines	0.009
	UNDPPH	0.005	PlanUSA	0.009

The number of connections in each sector were as follows: WASH (19%), shelter (40%), power (8%), transportation (8%), education (10%), and health (15%). Half of the sectors examined have formal clusters yet their network activity differed dramatically. Shelter for example had a high number

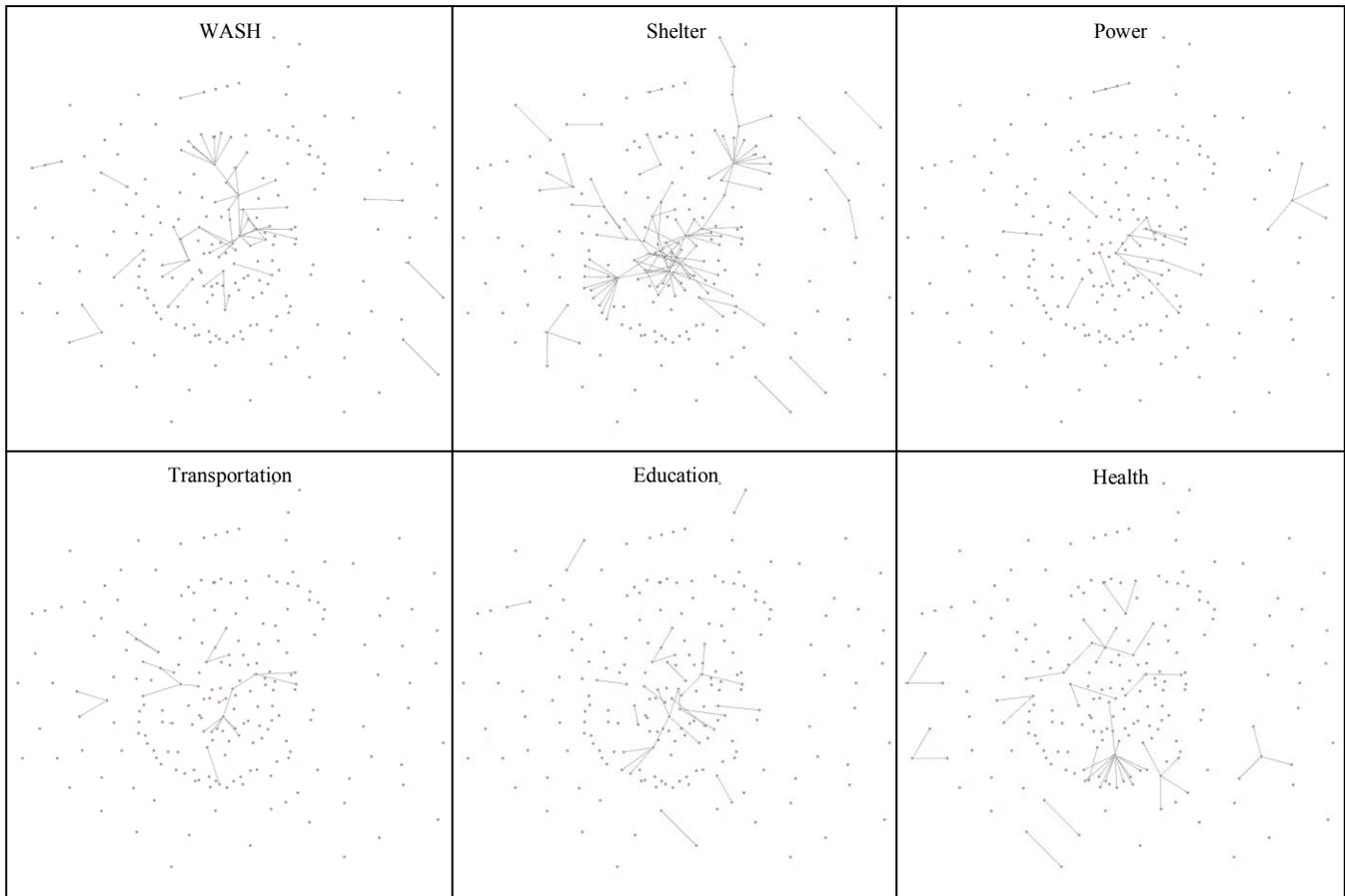


Fig. 2. Organizational Sector Sub-Networks

of organizational links. WASH and health, which each also have a cluster, saw significantly less activity even though there is equal amounts of work occurring in these areas. From Figure 2, we can see that shelter appears to be the only sector where widespread connection between organizations over Twitter is occurring. The other five sectors show activity, although many of these mentions were isolated, suggesting information did not circulate.

Examining the most central organizations lends further insight. In-degree is measured as the number of ties that a node receives – in this case the number of times they were mentioned. Out-degree is the number of ties that were directed out – or how many other organizations they mention. The top five organizations in each measure and sector are significantly different. We see that large NGOs are the most dominant organizations that mention others and those mentions appear to be mostly governmental or multi-lateral entities. A list of the top five in-degree and out-degree users for each sector are presented in Table 3.

From a network structural stance, NGOs were found to frequently act as boundary spanners between the public at large and government entities. This crucial role allows for more rapid dissemination and connection of information through traditional outlets such as media and individual user accounts. These alternative users are found on the peripheral of the network and government entities on the interior. In addition to

information dissemination, tweets demonstrated active interaction and collaboration between organizations such as this example: ‘55,709 people across 23 “baranguays” were supported in yesterday’s Food distributions in #leyte with @WFP.’ This post by ACTED demonstrates a partnership with the World Food Programme and is a common theme in how NGOs are using the platform. Government agencies, in contrast are using it in a much different manner. Part of the reason that these entities are central yet have few posts is they are using Twitter as a distribution outlet. For example, the National Disaster Risk Reduction and Management Council (NDDRMC) posted links for immediate release of situation reports (SitReps). These posts are used mainly as a means to direct to a more formal outlet. USAID had more tailored messaging, but still used Twitter as an outlet for links to fact sheets.

B. Content Analysis

In addition to network analysis of tweets, we examined keywords in messaging in the five months after Haiyan. Three areas emerged that sum up broad categories that were seen as intended use of tweets across all organizations. These include *needs, response, and impact*. Overall, we found that approximately 30% of tweets were needs requests, 50% were response related, and 15% were impacts. The lower occurrence of impacts may have been associated with the time of data collection as many projects were still underway.

1) Needs

Similar to individuals, organizations also used tweets as a means to draw attention to population needs. This was done from a funding standpoint, as many relied on Twitter as a means of garnering financial support for relief and recovery efforts. The following tweet shows one example of this: *'We're only \$151 shy of goal on @GlobalGiving to help families after Typhoon #Haiyan! Help fully fund this today!'* There was also a particularly high use of embedded urls to direct followers to third party websites for additional information that could expand on Twitter's character limit. Organizations were comfortable asking for additional needed support to fill gaps in their capacity. Linking the previous recommendations on increasing the use of mentions, these calls for human and material resources could be directed to specific organizations and users to solicit feedback in discipline specific fields. The current clusters provide a space for organizations to seek technical or discipline specific consultation – extending needs requests for these topics to Twitter could allow for a greater response of experts and more rapid return on requested resources. The clusters themselves could also start using Twitter more actively to distribute information. The shelter and camp coordination clusters each had an active account and were seen to be central in information flows in the network. Based on the high levels of connectivity seen in the shelter sector network, it appears that Twitter messaging was supported from within the cluster, resulting in its successful implementation. Tweets centered on needs quickly transitioned to impacts organizations were claiming on the ground as work commenced.

2) Response

Organizations posted a significant portion of information on *where and what* their efforts focused. This area has the largest potential to impact virtual coordination. Geographical locations were commonly mentioned, such as the municipality or province where work was starting. Geo-tagging however proved not to be used widely as tweets appeared to be filtered through main offices, thus limiting benefits from coordinate locations. Encouraging staff on the ground to use Twitter for site updates could prove useful to leverage the geotagging features of Twitter. It appears that this was not used by any of the organizations studied. Sector knowledge was also immensely central to the response theme such as demonstrated by the following example: *'At the core of our #Haiyan response is protecting rights of children, making sure their needs are met & their voices heard. #PlanResponds'* In line with the clusters, many of these sectors that were mentioned adhered to terminology used by this system, but there was no uniformity in the messaging. Duplication of services is one of the largest concerns for organizations. In addition to informing donors of action, these messages afford the opportunity to see what activities are occurring in their areas of implementation. It still remains difficult for organization to find this information and a more uniform tagging system could assist to remedy this problem.

3) Impact

Although less prevalent, messaging on organizations' stated impacts were the final messaging theme encountered. There was clear communication on the number of items

distributed, value of projects, or other quantifying metrics. This likely stems from why organizations seek to use Twitter in the first place – as a means for reach and publicity. Information was similar to the following example: *'10,000 most vulnerable families affected by #Haiyan/#YolandaPH to receive emergency cash grants as recovery aid.'* Tweets such as this one may be intended for the broader public, but they also provide concrete numbers and information for other organizations to adapt and inform their own actions.

VI. CONCLUSIONS

Coordination models for post-disaster reconstruction and management currently lack concrete implementation tools. We have addressed this gap by analyzing Twitter as a means of sustained communication that can assist reconstruction managers in working towards better coordination. By forming concise messaging that intends to inform, not manage processes, Twitter use constitutes a unique form of coordination. This platform should serve as only one of many diverse forms of communication where coordination actually manifests. The platform's flexibility has led to multiple uses, as has been shown between NGOs and government entities. This differing use situates Twitter well as a common ground for organizations to virtually gather in exchanging information.

In the network analyzed, NGOs appeared to play a linking role between peripheral nodes and government agencies. While governments had less mentions, they were more central actors in the network. Following our network analysis it is evident that many organizations fail to establish formal lines of communication via mentions. It is hard to determine who actually views information on Twitter, but increasing the use of formal lines of messaging through mentions is one way that entities can increase visibility of information and indirectly form the foundation for coordination. We saw that many entities, especially governments do not make use of mentions. Our analysis only focused on formal connections (mentions) as these were the most likely to be viewed by the exchange recipient. For tweets that did not have mentions, there was rich information in these messages but actually tracking its intended users is difficult, especially in the disaster context where simple and direct information is needed. For practical use, staff members should not have to dig for information. Increasing the use of mentions could greatly help to increase knowledge flows and ensure that information reaches its intended audience. Based on the roles that we saw organizations take on, this simple modification to messaging will assist to connect organization within and across sectors.

Similarly, the sectors we examined were sharing useful information but it was likely hard for users to find and track content. One of the hallmark features of Twitter is the hashtag. This allows for systematic searching and organization of information, yet it is underused by organizations to identify content. One has only to look at the success of tagging for disasters in the Philippines to recognize the enormous potential that remains. The country has one of the most developed tagging schemes that is widely adopted by the population and backed by the government. For every typhoon, there is a hashtag that individuals adopt (e.g. #YolandaPH). There is also a concise set of hashtags that users employ to communicate

and identifying messaging. Adopting similar tracking for sectors would consolidate information by topic and help get usable data into the hands of those who need it. Some sectors, such as shelter, are more advanced in their use of Twitter and piloting this system there could be the first step to wider adoption by organizations. If successful, this application could be expanded across existing clusters as a virtual communication mechanism to transition from short-term response to long-term reconstruction.

Finally, many organizations have started to recognize Twitter as a legitimate means of communication, but the platform still has a long ways to go. By encouraging use by staff members and regularly making use of an organization account its potential can be expanded further. Many aid workers already rely on Twitter for news and updates while in the field. This practice holds even greater potential should organizations provide resources of where to find reliable information. In general, tweets have shown to be reliable information, but enhancing and promoting recognized sources will help to ensure quality communication.

REFERENCES

- [1] T. Malone and K. Crowston, "The Interdisciplinary Study of Coordination," *ACM Comput. Surv.*, vol. 26, no. 1, pp. 87–119, Mar. 1994.
- [2] R. Chen, R. Sharman, and R. Rao, "Coordination in Emergency Reponse Management," *Commun. ACM*, vol. 51, no. 5, pp. 66–73, May 2008.
- [3] UN OCHA, "Cluster Coordination," *United Nations Office for the Coordination of Humanitarian Affairs*, 2014. [Online]. Available: <http://www.unocha.org/what-we-do/coordination-tools/cluster-coordination>. [Accessed: 18-Jul-2014].
- [4] G. P. Smith and D. Wenger, "Chapter 14: Sustainable Disaster Recovery: Operationalizing An Existing Agenda," in *Handbook of Disaster Research*, New York, NY: Springer, 2006, pp. 234–257.
- [5] S. Faraj and Y. Xiao, "Coordination in Fast Response Organizations," *Manag. Sci.*, vol. 52, no. 8, pp. 1155–1169, Aug. 2006.
- [6] J. Le Masurier, J. O. B. Rotimi, and S. Wilkinson, "A comparison between routine construction and post-disaster reconstruction with case studies from New Zealand," Birmingham, U.K., 2006, pp. 523–530.
- [7] A. Mills, R. Chen, J. Lee, and H. R. Rao, "Web 2.0 emergency applications: how useful can Twitter be for emergency response?," *J. Inf. Priv. Secur.*, vol. 5, no. 3, 2009.
- [8] S. Doan, B.-K. H. Vo, and N. Collier, "An analysis of Twitter messages in the 2011 Tohoku Earthquake," in *Electronic Healthcare*, Springer, 2012, pp. 58–66.
- [9] B. R. Lindsay, "Social Media and Diasters: Current Uses, Future Options and Policy Considerations," *J. Curr. Issues Media Telecommun.*, vol. 2, no. 4, 2010.
- [10] T. Hossmann, F. Legendre, P. Carta, P. Gunningberg, and C. Rohner, "Twitter in disaster mode: Opportunistic communication and distribution of sensor data in emergencies," in *Proceedings of the 3rd Extreme Conference on Communication: The Amazon Expedition*, 2011, p. 1.
- [11] R. Thomson, N. Ito, H. Suda, F. Lin, Y. Liu, R. Hayasaka, R. Isochi, and Z. Wang, "Trusting tweets: The Fukushima disaster and information source credibility on Twitter," in *Proceedings of the 9th International ISCRAM Conference*, 2012.
- [12] D. Murthy and S. A. Longwell, "Twitter and Disasters: The uses of Twitter during the 2010 Pakistan floods," *Inf. Commun. Soc.*, vol. 16, no. 6, pp. 837–855, Aug. 2013.
- [13] H. Purohit, A. Hampton, V. L. Shalin, A. P. Sheth, J. Flach, and S. Bhatt, "What kind of# conversation is Twitter? Mining# psycholinguistic cues for emergency coordination," *Comput. Hum. Behav.*, vol. 29, no. 6, pp. 2438–2447, 2013.
- [14] Y. Tyshchuk, C. Hui, M. Grabowski, and W. A. Wallace, "Social Media and Warning Response Impacts in Extreme Events: Results from a Naturally Occurring Experiment," 2012, pp. 818–827.
- [15] D. Velev and P. Zlateva, "Use of Social Media in Natural Disaster Management," *Int. Proc. Econ. Dev. Res.*, vol. 39, 2012.
- [16] A. Kongthon, C. Haruechaiyasak, J. Pailai, and S. Kongyoung, "The Role of Social Media During a Natural Disaster: A Case Study of the 2011 Thai Flood," *Int. J. Innov. Technol. Manag.*, 2014.
- [17] B. G. Smith, "Socially distributing public relations: Twitter, Haiti, and interactivity in social media," *Public Relat. Rev.*, vol. 36, no. 4, pp. 329–335, Nov. 2010.
- [18] A. Chatfield and U. Brajawidagda, "Twitter tsunami early warning network: a social network analysis of Twitter information flows," 2012.
- [19] G. R. Olafsson, "Effective coordination of disaster response—the international perspective," in *7th International Conference on Information Systems for Crisis Response and Management, Seattle, Washington, USA*, 2010.
- [20] H. Gao, X. Wang, G. Barbier, and H. Liu, "Promoting coordination for disaster relief—from crowdsourcing to coordination," in *Social Computing, Behavioral-Cultural Modeling and Prediction*, Springer, 2011, pp. 197–204.
- [21] World Bank, "World Development Indicators," 2013. [Online]. Available: <http://data.worldbank.org/>.
- [22] M. Beck, C. Shepard, J. Birkmann, J. Rhyner, T. Welle, M. Witting, J. Wolfertz, J. Martens, K. Maurer, P. Mucke, and K. Radtke, "World Risk Report 2012," Alliance Development Works, Berlin, Germany, 2012.
- [23] EM-DAT, "EM-DAT: The OFDA/CRED International Disaster Database," Université Catholique de Louvain, Brussels, Belgium, 2014.
- [24] J. Masters, "Super Typhoon Haiyan: Strongest Landfalling Tropical Cyclone on Record," *Dr. Jeff Masters' WunderBlog*, 07-Nov-2013.
- [25] E. Del Rosario, "Effects of Typhoon Haiyan," Nation Disaster Risk Reduction and Management Council, Quezon City, Philippines, Situation Report No. 104, Jan. 2014.
- [26] CFE, "Lessons from Civil-Military Disaster Management and Humanitarian Reponse to Typhoon Haiyan (Yolanda)," Center for Excellence in Disaster Management & Humanitarian Assistance, Pearl Harbour, Hawaii, Jan. 2014.