INTER-ORGANIZATIONAL RESOURCE COORDINATION IN POST-DISASTER INFRASTRUCTURE RECOVERY

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Abstract

Despite significant advances in strengthening post-disaster recovery efforts, misaligned strategy and inefficient resource allocation are far too often the norm for infrastructure reconstruction. To examine the inter-organizational networks that form to coordinate resources for infrastructure reconstruction, we employed social network analysis in nineteen communities in the Philippines following Super Typhoon Haiyan, at six months and twelve months post-disaster. To build these networks, we analyzed interview, field observation and documentation data collected from non-governmental organizations, local governments and communities. A survey questionnaire was also administered to organizations working in selected communities to validate networks. Results from network analysis established that information was the most commonly shared resource by organizations, followed by financial, material and human resources. Government agencies had the highest actor centralities; however, qualitative data suggests that these roles were the result of obligatory consultations by international organizations and lacked legitimacy in practice. Findings further demonstrate that networks become more decentralized over time as actors leave and roles become more established, influenced by short-term expatriate contracts and the termination of United Nations supported cluster coordination. Findings could help organizations strengthen humanitarian response efforts by attending to resource allocation and knowledge sharing with other organizations.

Keywords: coordination, disaster recovery, social network analysis

Introduction

Disaster recovery lies beyond the capacity of single organizations and requires coordinated efforts (Balcik et al. 2010; Kapucu et al. 2010a). These extreme events bring together diverse organizations that must work together to aid communities on their path to recovery. Managing disaster recovery processes is therefore complex, as it requires coordination with organizations who follow different norms and practices in rapidly evolving contexts that are spread across geographic regions (Chen et al. 2008). Moreover, the inherent characteristics of disasters challenge the capabilities of routine communication systems (Kapucu 2006). Effective coordination amongst these organizations can

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reduce financial burdens, alleviate staffing deficiencies and improve service delivery (Balcik et al. 2010). The consequences of ineffective or failed coordination are high, as the absence of coordination can lead to wasted resources, unnecessary redundancy of service provision or failed reconstruction projects (Ritchie and Tierney 2011).

Despite the important role of coordination (Drabek 2002), there remain significant gaps in understanding the resources that are coordinated within inter-organizational networks. In particular, recent shifts in multi-lateral aid policy have changed the landscape of coordination in emerging economies following disaster events. The introduction of the United Nations humanitarian cluster system in 2005 provided an institutional framework that could be used across events (Steets et al. 2010). Composed of eleven sectors, the clusters are formalized coordinating bodies that are led by a pre-designated agency, such as the United Nations International Children's Emergency Fund (UNICEF) for the water, sanitation & hygiene (WASH) cluster. Upon deployment, clusters typically remain active for short periods (less than 2 years), but play an influential role in disseminating knowledge and information to organizations. Efforts include tracking programs that center on the '3Ws' – who, what and where. Coordination of expertise is a central tenant that appears through direct (in-person) and indirect (published material) communication.

The introduction of cluster coordination has altered how organizations engage in coordination activities. We lack an understanding of coordination practice under the humanitarian cluster system, including the types of resources that are coordinated across organizations and the types of actors that take on central coordination roles. A better understanding of this post-disaster coordination practice will help us enhance theory on how coordination impacts recovery. Further, disasters are often studied through the lens of a single period of time, yet we know that coordination practice and recovery efforts are dynamic and evolve over time. It is therefore critical to understand how coordination networks evolve and change over time in the recovery process. As such, we propose three research questions:

1. **What types of resources are most frequently shared in post-disaster inter-organizational networks?**
2. **What actors are most central in post-disaster inter-organizational networks?**
3. **How do post-disaster inter-organizational networks change during early recovery?**

We address the first two questions by examining networks that form to coordinate different resources using social network analysis. Social network analysis also enabled us to identify which actors take on central roles in coordination activities. To answer the third question, we analyzed and compared networks within the same communities at two different time periods during the recovery process, the first at six months post-disaster, and the second at twelve months post-disaster. Our questions focused on early recovery efforts within the first twelve months following Typhoon Haiyan in the Philippines, after emergency aid (e.g. tents and food), as this stage involved the most critical decisions that will contribute toward long term development.

Disaster Recovery

Each disaster that strikes a community impacts social, economic and infrastructure systems. Communities, governments and organizations employ varying approaches to deliver aid and reconstruct infrastructure following these events. Scholars have proposed four post-disaster phases that include: (1) mitigation (e.g. reduction in hazard vulnerability); (2) preparedness (e.g. early warning, disaster management planning); (3) response (e.g. search, rescue, debris removal and emergency housing); and (4) recovery (e.g. developmental reconstruction to enhance future resilience) (Berke et al. 1993; Mileti 1999; O'Brien et al. 2010). These stages are helpful in conceptualizing the time scale

of reconstruction, but we acknowledge, along with other researchers (e.g. Smith and Wenger 2006), that recovery is a non-linear, complex process. The response phase has long been a core tenant of disaster management theory (Drabek 1985), yet there is an increasingly fuzzy boundary of the recovery phase into other fields of study. Rather than view the fields of disaster management and project management as disjointed, we echo recent calls in literature to study their intersection (e.g. Ingirige 2016) in order to better theorize on the impact of project management in the disaster process cycle.

Coordination in Disaster Recovery

Scholars have made significant strides towards a unified understanding of factors that expedite, or hinder, recovery. One important factor that has emerged is coordination of stakeholders (Jordan et al. 2016; Quarantelli 1997). We define coordination here as Drabek (2007) did, the process of social and material interactions among interdependent organizations that share a common goal of community recovery. Coordination of actors serves to unify strategy (Jahre and Jensen 2010), reduce duplication of services (Nolte et al. 2012) and reduce the waste of resources (Okhuysen and Bechky 2009). The product of coordination is theorized to produce faster recovery times for communities and deliver infrastructure with greater functionality. This first point of temporality is of particular importance in post-disaster humanitarian contexts. Temporal coordination can be thought of as the "*process structure imposed to intervene and direct the pattern, timing, and content of communication in a group*" (Montoya-Weiss et al. 2001). Past studies have focused on this important characteristic of coordination, suggesting that different phases of response and recovery require different information, equipment and management skills (Comfort 2004), although these models need validation through longitudinal and empirical evidence of coordination practice.

While there are sparse examples of the impact of successful post-disaster coordination, there are an abundance of examples that demonstrate the failings when coordination does not occur (Jordan et al. 2015), including fragmented service delivery and the inefficient allocation of resources. Thus, there is a need to better understand and unpack coordination as it occurs in practice, including identifying what resources are coordinated, how coordination networks are formed and what structure these networks take, to eventually analyze how coordination practice influences the success or failure of recovery efforts. Unfortunately, while coordination frameworks within management are robust (e.g. Jarzabkowski et al. 2012), coordination theory within the disaster context is still in its infancy. There is a need to specifically understand coordination in the disaster context, which differs from coordination in organizations. The disaster context is set apart because sudden and unexpected events create a context of unpredictability (Kapucu et al. 2010a; Salmon et al. 2011), which increases uncertainty. The foremost uncertainty is disasters themselves, as they vary by nature, location, timing and intensity (Balcik et al. 2010). Uncertainty also continues to persist as recovery operations evolve from new and changing information, task flows, organizational structures, the political environment and post-disaster funding levels (Chen et al. 2008). In addition, disaster coordination heavily diverges from coordination in other contexts due to time pressures to deliver services (Faraj and Xiao 2006, Abbasi and Kapucu 2012). This leads to fast decision making, where mistakes can be catastrophic and poses constraints on responders' capabilities to act and analyze coordination problems (Chen et al. 2008). Finally, the contractual nature of delivering infrastructure through the humanitarian system means that organizations have a short term presence in contexts, differing from other organizational environments where there is a long-term presence.

Effective coordination amongst organizations assisting in disaster recovery is crucial, as critical decisions must be made to allocate resources in a rapidly changing, dynamic environment (Kapucu 2006). Meeting resource demand with supply is of particular concern in disaster relief activities. For

example, one third of the relief containers delivered after the 2004 Indian Ocean tsunami continued to be blocked at airport customs five months after the disaster, resulting in severe delays in delivering service provision to affected communities (Balcik et al. 2010). While coordination activities surface to address the challenge of resource scarcity, the arrival of numerous organizations simultaneously confounds the complexity of allocating resources (Quarantelli 1997). While commonly coordinated resources have been classified into categories that include *material* (e.g. equipment, transportation), *human* (e.g. labor workforce), *information* (e.g. expertise, contacts) and *financial* (e.g. joint funding projects) resources (Chen et al. 2008; Frimpong et al. 2003; Jahre and Jensen 2010), we do not yet know which of these resources are coordinated and shared most frequently, which would allow us to identify potential inefficiencies in resource allocation.

Cluster Coordination

Disaster coordination has evolved over the last decade. To date, the literature has largely focused on emergency response activities, with a dearth of research as to how coordination occurs in later recovery stages and the influence of coordination on recovery outcomes. The earliest traces of formalized, modern humanitarian coordination come from the United Nations General Assembly resolution 46/182, dating back to December of 1991. In these early efforts to coordinate, the United Nations, in partnership with the national government of the affected country, was designated as the central actor in charge of coordination. Following early organizational theorists, traditional centralized structure was anticipated to lead to more effective coordination of activities, however empirical examples (e.g. Kellogg et al. 2006) provide evidence of decentralized behavior as the dominant force in organizational action. A shift occurred in 2005, when the humanitarian cluster system was introduced. The clusters, while still highly structured, transitioned away from central control towards guidance and collective action on behalf of responding organizations, paralleling the grassroots movement in development (Willis 2011). Clusters are led by one, or in some cases two, lead organizations when activated, but receive support from the United Nations Office for Coordination of Humanitarian Affairs (UNOCHA). For example, the Shelter Cluster is typically headed but the International Federation of the Red Cross (IFRC) and United Nations High Commissioner for Refugees (UNHCR). There is a dearth of research that has analyzed coordination under the cluster system. Research is needed to identify how the cluster system has influenced resource coordination amongst organizations, and how, through longitudinal analysis, the eventual end of the cluster system influences later resource coordination.

Governmental Agencies

Government agencies typically assume a lead role in coordination of recovery efforts, although the extent of their role often differs between developed and emerging countries. Past shortcomings of government managed reconstruction programs in developing countries (e.g. Powell 2011) point to the need to re-conceptualize the role of these organizations in recovery schemes. Government agencies differ from international non-governmental organizations (NGOs) and United Nations bodies in that they are permanently embedded within the social fabric of communities. Therefore, governments often have higher social capital with affected populations and can draw from established channels of communication (Kapucu et al. 2010b). However, these governmental agencies are typically heavily bureaucratic and often lack the flexibility required in quick response scenarios. In some regions, these agencies may also fail to possess necessary experience and knowledge required to manage emergencies effectively. Moreover, intergovernmental relationships are known to include poor consensus among actors, low levels of trust, contested authority and limited capacity for external actor participation (Kapucu et al. 2010a), which are obvious barriers to coordination. There is therefore a need to better

understand the central actors that coordinate recovery efforts in post-disaster environments and how government agencies strengthen, or conversely limit, coordination in international responses.

Social Network Analysis

Social Network Analysis (SNA) is a methodology used to analyze social structures by conceptualizing social relationships as interconnected networks of actors (El-Sheikh and Pryke 2010). Networks are geometric constructions made from sets of items called *vertices* with connections between them called *edges*. In sociology, vertices are named *actors* and edges are called *ties* (Newman 2003). The fundamental purpose of social network analysis is to model relationships between actors and depict the structure of a social group through mathematical and graphical methods by measuring the number, the path and the strength of those ties (Pryke 2012; Wasserman and Faust 1994). From multiple available metrics, researchers can analyze network structures, how an actor is embedded within a social structure and how a social structure emerges from the micro-relations between actors (Kapucu 2005). In addition, graphical representations of networks can be generated which assist in visualizing network mechanics. Social network analysis can be used at two levels of analysis: (1) actor level or (2) network level. At the actor level, properties or attributes (e.g. age of an individual or organization) can be analyzed for their impact on ties and network traits. Properties of an entire network, such as centralization or density, can be calculated based on the types, and number, of ties connecting actors in the network.

Social Network Analysis in Disaster Coordination

Abbasi and Kapucu (2012) describe social network analysis as "*a theoretical lens and analytical tool for discovering the patterns of communications and its dynamics in crisis situations.*" Although social network analysis is not a new methodology, it is new in disaster research (Varda et al. 2009). As stated by Kapucu et al. (2011), social network analysis "*offers a unique opportunity to study the complex nature of disaster response.*" Presently, a limited number of studies have used social network analysis to understand post-disaster coordination networks, focusing on interactions among public, private, and nonprofit organizations following 9/11 (Kapucu 2005), inter-governmental and inter-organizational response to Hurricane Katrina (Kapucu et al. 2010a), evolving organizational response to the cycle of Floridian hurricanes (Kapucu et al. 2010b), and emergency responder and governmental collaborations during the 2012 Korean typhoon season (Jung 2013). As indicated, coordination is key to effective disaster recovery, with robust networks seen as being better able to respond promptly and effectively in service delivery (Kapucu 2005), and social network analysis can be a useful tool in modeling these interactions.

While social network analysis reduces and quantifies social structures, it also makes them visible and comparable across cases (Pryke 2004, 2005). Moreover, by mapping a visualized network, social network analysis can help people and organizations understand their impact and position within a network, and highlight reasons of success or failure in organizational strategy. While scholars have taken initial steps to use social network analysis in the disaster context, study of resource coordination has been narrowly focused (e.g. only information), and further, past analysis has taken a notably static understanding of coordination, when in fact disaster literature increasingly emphasizes the dynamic nature of recovery efforts. As such, we do not yet know how different coordination network structures form and evolve over time, which would help in the identification of how structure and inclusion of different types of actors influences long-term recovery efforts.

In summary, we aim to address the needs identified above by better understanding post-disaster coordination of recovery efforts, specifically, the types of resources that are coordinated, the network structures that emerge to coordinate these resources and how these structures change over time,

attending specifically to which actors are central and how the removal of the cluster system affects coordination. To accomplish this, we employ social network analysis, a novel lens through which to study coordination in the disaster recovery literature.

Method

To answer the proposed questions of what resources are coordinated, who are central actors and how do networks change during recovery, we selected to study early recovery efforts of organizations responding to Typhoon Haiyan in the Philippines. We employed social network analysis as a means to operationalize and compare coordination structures for four different types of resources – *material*, *human*, *information* and *financial* – across nineteen communities at two points in time. Operationalizing coordination with social network metrics for different resources at the community level allows for comparison across points in time, and, together with the qualitative data, allows us to understand why these networks emerged and changed.

Research Context

On November 8, 2013, Super Typhoon Haiyan (locally known as Yolanda) hit the Philippines with wind speeds of 320 km/h and gusts of up to 360 km/h, making it the fourth most intense tropical storm ever observed and the strongest to ever make landfall. Haiyan made its first landfall in Guiuan, Eastern Samar and crossed the country by heading westward towards Vietnam. In total, nine of the seventeen Philippine regions were hit by Haiyan, affecting more than 16 million people, damaging (partially or totally) more than 1.1 million houses and causing losses estimated at nearly 900 million USD (Center for Excellence in Disaster Management and Humanitarian Assistance 2014). Due to significant damage, housing, water and sanitation infrastructure quickly became key priorities of the government and international community in the recovery effort (National Economic and Development Authority 2013). We focused on the coordination of resources needed by organizations to deliver these infrastructure services in recovery, along with other supporting programs, such as livelihood assistance and social development. Examples of supplementary livelihood and social programs included boat construction for fishermen and gender-based violence awareness. An example of coordination across these sectors included the sharing of schedules and training dates to avoid overlap. The delivery of other infrastructure, such as transportation and power, were not included because these systems were restored within two months after the typhoon, with long-term investments planned at an uncertain time in the future.

Community Selection

Administratively, the Philippines is organized by regions, provinces, municipalities, cities and, at the smallest administrative division, the barangay. Our unit of analysis focused at the barangay level, or *community* level. We selected communities in consultation with organizations working in the field based upon criteria that included: (1) similar socio-economic status, (2) similar degree of damage caused by Haiyan, but that may differ in cause (e.g., flood, wind), (3) similar population size and (4) differing number of organizations involved in the recovery effort. In total, 19 communities were selected that consisted of 6 communities in the province of Cebu, 11 communities in Leyte and 3 communities in Eastern Samar. Among the selected communities, 86 organizations carried out 309 total programs. We define a program here as a service delivered by a single organization. For example, a WASH (water, sanitation and hygiene) program might include various elements such as latrine and water construction, but was managed uniformly by an organization, thus constituted a single service. For our analysis, we focused on the coordination of organizations involved in the selected communities.

Data Collection

Longitudinal data was collected in three primary forms: (1) semi-structured interviews, (2) observations and (3) surveys. The research team collected data within each of the selected communities through field visits at approximately six months and twelve months post-disaster. These field visits were conducted for three and four months, respectively. Six months was selected for the first time period as this immediately followed emergency services and signaled the start of early recovery efforts that focused on delivering infrastructure. Twelve months was selected as the second time period because this aligned with the completion of planning and design for housing programs, coincided with the ongoing construction phase of infrastructure projects and was after the departure of the humanitarian cluster system. During the first visit, 32 semi-structured interviews were conducted with local government officials, NGO officers and community members. Questions aimed to understand with whom organizations were coordinating, what was being coordinated and through what means. Example questions included: *Is your organization currently coordinating rebuilding efforts with another NGO, organization or government?* and *What types of resources are you sharing?* During the second field visit a similar demographic was targeted for interviews. A total of 167 individuals were interviewed during this period. Questions for this period aimed to understand changes that had occurred over the first year of recovery and included questions such as: *In recent months, how has coordination changed?* For all local staff and community members interviewed that natively spoke Tagalog, Cebuano or Waray, a local translator was provided. Interviews were transcribed and translated into English.

Additional data included documentation from organizations, government agencies and humanitarian clusters. These included meeting minutes from coordination meetings, partnership agreements, planning guidelines and other textual sources shared between organizations. Field observations of inter-organizational coordination meetings, organizational meetings and informal gatherings were also documented extensively with field notes. The duration and scope of the study allowed for the researchers to build significant trust with organizations and observe substantial interactions during informal settings.

Due to the complexity associated with dynamic coordination networks in early recovery, we chose to build network data from the expansive qualitative data that was collected. Here we argue that traditional social network analysis data collection methods (e.g. surveys) would be insufficient to capture the entirety of coordination structures due to the dynamic environment, staffing and organizational turnover, but can be a means to validate collected data from researcher observations. This method represents a novel approach to triangulate qualitative data, which addresses a major limitation of traditional social network analysis studies – their inability to capture complete networks (Scott 2012). Addressing the dearth of knowledge on resource coordination in literature, we focused on four types of resources previously categorized in coordination practice. These resources included: *material* (e.g. equipment, transportation), *human* (e.g. labor workforce), *information* (e.g. expertise, contacts) and *financial* (e.g. joint funding projects). Using interview transcripts, field notes and documentation, a list of known organizations working in each of the 19 selected communities was compiled. This list was then converted into a matrix format common for network data. The first author, who was present during field observations and for all interviews, was then asked to complete a matrix for each of the four types of resources coordinated in each of the communities. Separate matrices were generated for six months and twelve months. Multiple subsequent passes were completed after reviewing collected qualitative data. This generated four resource network matrices for each community at six months and four resource network matrices at twelve months that described coordination structures. An additional network was compiled for each time period, at six and twelve months post-disaster, that combined the number of resources shared. The research team considered

undirected ties between actors, implying that the link between actor A to actor B is the same as the one linking actor B to actor A. This assumption was used given how the data was generated from observation and because a single value from researcher observation allows for more consistent evaluation of social relationships between actors.

Concurrent to the generation of network matrices by the researchers, an online network survey was sent to all 86 organizations known to be working in selected communities. These survey questionnaires served as a method to validate qualitative network construction by examining a sample of network actors and connections. Questions asked general information about the organization's response and recovery programs and network questions regarding their coordination with other organizations and agencies. The purpose of the surveys was not to generate entire networks, but instead provide a sample of organizational responses that could validate researcher generated matrices. The survey asked organizations to confirm their presence in the selected communities and identify organizations with whom they coordinated at six months and twelve months. For each period, the organization was asked to identify what resources (material, human, information or financial) were coordinated. The survey was sent to mid-level management staff with experience working in the identified communities. In the event that this individual was not able to answer questions regarding inter-organizational coordination, a second, or in some cases third, contact was asked to provide responses. Twenty of the 86 organizations responded to the survey, resulting in a 23% response rate. As these responses covered 52 of the 309 identified programs, it confirms that collecting social network analysis data through surveys would not have been sufficient to capture the entire coordination networks, but can be used as a means to validate qualitative data.

Analysis

We classified organizations into three different categories: (1) local organizations, (2) international organizations and (3) governmental agencies. While important to recovery, we chose to exclude community religious entities, such as local churches, as they often played a lesser role in infrastructure reconstruction based on field observations. Here, we define *local organizations* as either organizations based in the Philippines or international organizations that had a permanent office in the Philippines. In contrast, *international organizations* are not based in the Philippines. Among the identified *governmental agencies*, only two were considered as being active in infrastructure related activities. The first was the Department for Social Welfare and Development (DSWD) and was involved in shelter cash distribution with its Emergency Shelter Assistance (ESA) program, as well as in relocation processes. The second governmental agency, the National Housing Authority (NHA), was involved in site development and financing of relocation sites.

Based on the collected data matrices, 190 networks were built using Netminer4, social network analysis software developed by Cyram. Metrics were calculated at the actor level (degree centrality) and at the network level (degree centralization). At the actor level, centrality measures help to determine the prominence of an actor in a network. The context of the network in which the actor is embedded will determine whether negative or positive influence is associated to prominence in the network (Pryke 2005). Three types of centralities could have been used in calculations: degree, betweenness and closeness. Because we are interested in the activity of an organization within the coordination network, we adopted degree centrality, which is considered a measure of the activity of organizations (Freeman 1978). Degree centrality is defined as the count of the actor's connections divided by the maximal number of potential connections that an actor may hold in a network (Wasserman and Faust 1994). As suggested by Kapucu et al. (2010a), organizations that have more ties are more powerful and advantaged in the network. High degree centrality thus implies higher involvement of an actor in

activity with the rest of the network (Pryke 2004). In contrast, betweenness centrality would have been used if our focus was on the ability of organizations to connect subgroups, while closeness centrality could have been used to examine path dependencies in coordination structures.

At a network level, the number of connected actors is the number of actors present in a network that share at least one tie with others, regardless of the weight that ties may have (e.g. number of resources shared). This metric is useful to assess the degree to which organizations in a community share resources with others. The density of a network is defined as the number of ties in the network divided by the number of possible ties. Its value varies from 0 to 1; where a 0 implies that no actors are connected and a 1 represents complete connectivity between all actors in a network. Network density is treated as a measure of the overall coordination among the organizations in the network (Topper and Carley 1999), which, in our research, can assess how much organizations tend to share particular resources with others. Network degree centralization is a relative measure of actor degree centralities in relation to the entire network, and varies from 0 (all actors are equal) to 1 (one central actor appears). This metric shows if there is one organization that tends to share resources (network degree centralization = 1), or if all organizations share the same amount of resources (network degree centralization = 0). Note that centralization depends on the number of organizations included in a network. In order to allow comparison between communities that have a different number of involved organizations, we normalized network centralizations. For each community, the network centralization, dependent on the number of actors, was divided by the highest actor degree centrality that an actor could have, if it was the only central actor in the community.

Networks were analyzed with the same number of organizations for both time periods considered. This assumption provides greater insight to answer who is central in networks and how they change over time. This assumption impacts our analysis in several ways. If an actor was isolated at one of the time periods, it suggests that they may either be present without coordinating, or absent from the recovery effort during that time period. While our qualitative data can assist in determining the answer to this question, both situations are considered the same in the network analysis. Further, if an actor joined the recovery effort after six months, they were included as an isolated actor at six months in order to keep the number of organizations static, which allows for network metric comparisons.

As part of the approach used to triangulate qualitative data, we conducted comparison testing between the researcher generated matrices and a sample of organizational surveys that were collected. This validity check was done by comparing each organization's survey answer at the actor level with the data constructed from researcher observations, interview data and field notes. For a specific resource (e.g. information), the number of researcher and organization link disagreements were totaled in each community network. For instance, in a community where 14 organizations were identified, one organization shares resources with 8 others. If for a specific resource, the organization and the researcher were in agreement for all ties except one, the average score would be $0.07 - 1$ disagreement among 13 potential ties. Note that we consider agreement for both coordination between two actors, and the lack of coordination. The same process is repeated for every answer received from each organization survey, for each resource, at six months and twelve months. We then calculated the mean of these disagreement scores for each community.

Findings

For each of the communities studied, we compiled network metrics to answer the three research questions, which included identifying what resources are coordinated, what actors are central and how networks change over time. We will first present a summary of the networks, resource coordination

trends and organizational demographics, followed by our analysis of two different time periods, six months and twelve months after the disaster.

Resource Coordination

Based on the different types of resources analyzed (material, human, information and financial), social network analysis helped identify the most common resources shared. Resource coordination can be examined by looking at three metrics: (1) percent of organizations coordinating a resource in a network; (2) mean density of network for type of resource; and (3) degree centralization of each resource network. We present means at six months and twelve months for all networks in Table 1. We will return to discuss these changes in our discussion of network evolution. A summary of key metrics for each community are provided in Table 2.

Table 1: Individual Resource Coordination Networks

Resources	Percentage of Organizations Coordinating Resource			Mean Density			Mean Degree Centralization		
	6 months	1 year	Change	6 months	1 year	Change	6 months	1 year	Change
Material	28%	16%	-42%	0.028	0.016	-44%	0.147	0.109	-26%
Human	10%	7%	-27%	0.009	0.006	-29%	0.076	0.071	-7%
Information	80%	42%	-48%	0.219	0.070	-68%	0.451	0.247	-45%
Finance	28%	21%	-27%	0.029	0.020	-32%	0.133	0.104	-22%

Table 2: Summary of Combined Resource Network Metrics

Community	Number of Actors	Number of Connected Actors		Density		Degree Centralization		Mean Degree Centrality	
		6 months	12 months	6 months	12 months	6 months	12 months	6 months	12 months
1	14	9	8	0.187	0.110	0.043	0.025	0.264	0.132
2	21	18	11	0.186	0.086	0.163	0.126	0.229	0.119
3	16	14	10	0.208	0.108	0.173	0.104	0.283	0.142
4	14	10	6	0.198	0.077	0.139	0.112	0.253	0.121
5	16	13	6	0.200	0.042	0.204	0.122	0.300	0.075
6	19	15	7	0.175	0.041	0.174	0.084	0.228	0.070
7	14	13	8	0.319	0.11	0.157	0.115	0.495	0.187
8	17	16	7	0.294	0.059	0.129	0.157	0.390	0.096
9	16	10	6	0.100	0.050	0.071	0.084	0.133	0.083
10	9	7	2	0.250	0.028	0.055	0.055	0.306	0.056
11	17	14	10	0.235	0.132	0.121	0.145	0.294	0.206
12	11	8	5	0.200	0.091	0.110	0.092	0.200	0.164
13	17	14	7	0.250	0.051	0.106	0.091	0.287	0.096
14	19	18	5	0.251	0.029	0.217	0.073	0.345	0.058
15	12	11	5	0.242	0.076	0.107	0.074	0.242	0.091
16	13	10	4	0.256	0.051	0.139	0.130	0.321	0.103
17	26	18	12	0.114	0.052	0.182	0.114	0.138	0.083
18	16	14	7	0.267	0.100	0.251	0.180	0.392	0.192
19	15	12	4	0.248	0.038	0.165	0.080	0.314	0.057

Combining findings from the percent of organizations sharing a resource, the network density and the degree centralization analysis, our findings shows that *information* was the most frequently shared resource, although there is a wide variation in its content. An example of coordinating information

was sharing lists of beneficiaries within communities between two or more organizations, or reporting the cost of infrastructure being constructed. Information tends to be easier to coordinate as it can be shared relatively freely without the need for managerial authorization within organizations. From literature, we know that information has the lowest demand on organizations, and is important, but can be superficial, lacking the theorized monetary benefits seen in more intensive types of resource coordination (Neeraj Jha and Misra 2007). After information resources, organizations tended to share *material* and *financial* resources with the same ease at six months. These resources are more complicated to coordinate as they require administrative mechanisms to put into practice, however, coordinating these resources can help eliminate redundancy, particularly in resource-constrained, post-disaster environments. Examples of material coordination included sharing tools between reconstruction projects in a community, while an example of financial coordination was a mutual donor agency for multiple projects within a community. Finally, *human* resources are seen as the rarest resource shared at six months. For many organizations, a skilled workforce was harder to come by than funding. As a result, there was a hesitance to coordinate labor and it was common to see wage wars between organizations for carpenters and masons. For example, one NGO project manager said, "W*hen the foreign NGOs come in they would up the price for labor and materials. So there was an initial, shall I say, there was an initial dislocation of the pricing scheme. It got abnormally high for the projects. So how to deal with that*?"

All of the resources analyzed faced a decrease in coordination between organizations over time, using mean density and mean degree centralization as a proxy. Although information is the most shared resource, it faced the highest decrease over time – a 68% mean network density loss. Following initial program planning, there was less uncertainty and information demand as organizations solidified infrastructure designs. Material and financial resources had less density loss over time, with financial coordination 32% lower and material coordination 44% lower at twelve months than six months. Finally, human resources, was 29% lower at twelve months when compared to six months. This serves to answer our first research question which asked what resources are most frequently coordinated in post-disaster inter-organizational networks.

Analyzing the types of resources coordinated highlights the need to better understand how materials and, in particular, human resources, can be coordinated and shared more effectively in resource constrained environments. The inefficiencies that resulted in a lack of coordination, including price escalation and 'poaching' trained labor from other organizations, caused schedule delays and increased costs which ultimately resulted in scope reduction or unfinished projects. Furthermore, while we certainly expect coordination channels to consolidate over time, the rapid decrease in network density demonstrates the magnitude of resource coordination drop-off. The consequences of this drop resulted in higher rates of duplication of services after twelve months, in one case leading to entire communities receiving two or three iterations of shelter.

Centrality of Organizations

Local organizations
To address our second research question, which asked who are the most central actors in post-disaster inter-organizational networks. We will discuss themes that emerged for local organizations and then government agencies. Among the 86 organizations identified in the considered communities: 38% were local, 49% international and 13% had an unidentified origin. This latter percentage may seem high, but these organizations only accounted for 4% of the 309 programs analyzed, which demonstrates the limited role of these organizations in the recovery effort. They were most frequently small local churches whose presence was temporary and had limited input in the recovery process (mainly food distribution at early stages). On the other hand, local organizations, while a minority,

carry out over half of all the identified programs among communities. This suggests that local organizations tend to be involved in communities more than international organizations, who may focus their attention on a smaller number of communities.

Network metrics provide additional support for local organizations' important role in coordination. At six months, local organizations had a mean degree centrality of 0.297 in comparison to 0.267 for international organizations. At twelve months, mean degree centralities decreased to 0.154 for local organizations and to 0.068 for international organizations. Using a two-sample t-test, we find that there was not, however, a statically significant difference between international organization centrality (M= 0.267, SD= 0.217) and local organization centrality (M= 0.297, SD= 0.306) at *six months*; t (296)=-0.960, p=0.338. There was a statistically significant difference between international organization centrality (M= 0.068, SD= 0.129) and local organization centrality (M= 0.154, SD= 0.196), however, at *twelve months*; t(296)=-0.960, p=0.000. This suggests local organizations tend to take a more central role in longer term resource coordination, perhaps because of more effective allocation, and consolidation, of resources over time. For example, one NGO staff member said, *"Implementation according to our guidelines may change according to how we see the needs of the community and also the needs and capacities of our teams. …and then we're looking with the resources that we still have. We still have savings under our administrative cost, particularly on salaries… so we modify the budget."* Local organizations had a resurgent need to coordinate with excess funding, whereas international organizations did not have a need to reallocate resources as their program budgets were more rigid. Aligning with past theory, which suggests that coordination demands may change as recovery progresses (Comfort 2004), our findings also suggest that resource coordination demands may be different for local and international organizations.

Government Agencies
Only two governmental agencies were considered to be active in infrastructure reconstruction; each had fundamentally different behaviors in coordination practice. The Department for Social Welfare and Development (DSWD) was active in all of the studied communities and had a recurrent central role, while the National Housing Authority (NHA) was only present in 26% of communities and had a more limited role. DSWD was present in all of the 19 considered communities at six months, and in 89% of communities at twelve months. Further, in all but five of the communities, DSWD was the most central actor at both six and twelve months. As a general trend, centralities of this governmental agency decreased over time, but its relative importance remained the same as other organizations' centralities decreased. Our analysis showed that government agencies' involvement in communities depends largely on their approach and mandate. From the two agencies considered, DSWD was more active at the regional level, which trickled down to involvement at the community scale. NHA was focused at the national level, and its involvement was limited to a few relocation sites.

From the qualitative data collected, however, these coordination efforts were limited. For instance, DSWD tended to receive information, but did little to reciprocate. NGOs commonly felt that it was obligatory to contact the local government, in this case DSWD, but these exchanges often lacked any real discourse. In contrast, the government organizations were often fearful of losing support from NGOs if they criticized their actions. Therefore, despite occupying a central role in our network analysis, government agencies held a misaligned role with practice. Exchanges between government agencies and NGOs were also compounded by misunderstandings in technical language and jargon used to coordinate. For example, a newly hired Filipino NGO worker said, *"Actually I had to look up what a core shelter looks like and so I say that, oh, this shelter is the core shelter!"* This sentiment about naming conventions and function of the cluster system was common to almost all newcomers.

When we compared the role of government agencies with UNOCHA, the organization responsible for supporting cluster coordination, we found that DSWD held a higher centrality at both time periods analyzed. We use network metrics of UNOCHA here to represent cluster coordination as this organization was responsible for cluster reporting and provides a means to assess overall cluster trends. A comparison of mean degree centralities from government agencies, UNOCHA and all other organizations is shown in Table 3. Interestingly, NHA's centrality was opposite other actors, and slightly increased over time. This is likely because in-situ construction by other organizations started more quickly and NHA's projects commonly required development of new relocation sites which inherently took more time to plan.

Table 3: Mean Degree Centrality Comparison

	6 Months	12 Months
DSWD	0.734	0.453
NHA	0.187	0.202
UNOCHA	0.534	-
All Organizations	0.346	0.257

While governmental agencies were central actors at six months, an interesting trend emerged in their network role at twelve months – they were commonly positioned between two isolated sub-groups in the networks. Thus, despite limited authority at six months, these early connections led to their continued role to link organizations at twelve months. To demonstrate this, we have illustrated the community network of organizations for case 17 at six and twelve months in Figure 1. DSWD, circled, is central at six months and has a large number of connections, having a degree centrality of 0.500. At twelve months DSWD's resource coordination activity drops, holding a degree centrality of 0.167, but the agency spans two observable subgroups. If DSWD was not present in the coordination network at twelve months, four of the NGOs located at the bottom of the network would have been completely disconnected. This suggests that while early coordination may not involve the government in substantial dialogue, these organizations play an important role in long term linkages.
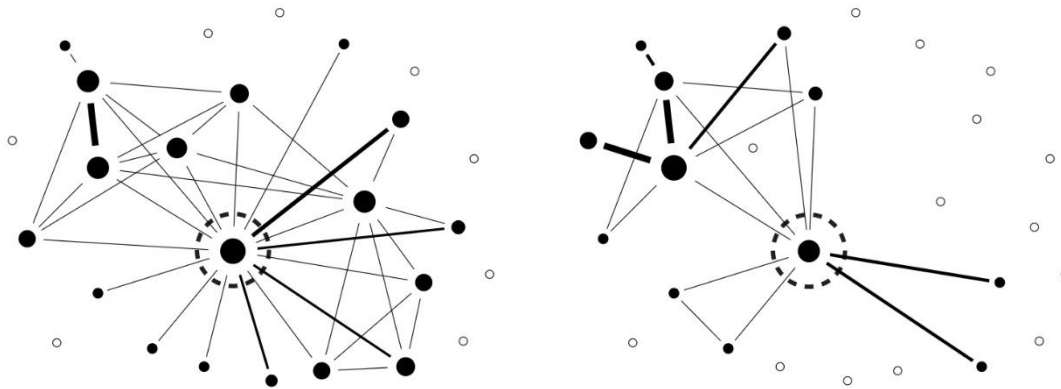

Figure 1: Impact of Government Agencies on Coordination

It is worth noting that DSWD was present in every community, therefore, the impact of limited government involvement cannot be discussed. By analyzing densities of networks, however, it appears that communities where DSWD was not central have a higher than average density at six months, and a lower than average density at twelve months. Therefore, these communities face the highest change

of density over time. Whereas there is debate in the literature on whether governmental agencies should take central coordinating roles in recovery efforts (Kapucu et al. 2010b; Powell 2011), this analysis suggests that governmental agencies do have an essential role in long-term resource coordination. It also implies that while the lack of a central governmental agency can be advantageous in the short-term, as it is associated with additional connections between potential actors, this lack of central government agency can be detrimental to long-term coordination when these connections are lost. In summary, we found that government agencies tend to be the most central actors during both time periods. International organizations have higher centralities over local organizations at six months and, conversely, local organizations have higher centralities than international organizations at twelve months, answering our second research question.

Network Evolution

Based upon the longitudinal network analysis, we present results for network evolution through the following metrics: network centralization, actor centralities, densities and number of connected organizations. The mean actor centrality of the combined resource networks was found to decrease by 26% over time. We also analyzed the change in the *number* of shared resources over time, which showed that the total number of resources shared decreases by 60% between the two periods examined. The centrality changes and the decrease in the number of resources shared suggest that organizations are less active over time.

Decentralization in Networks

Across all communities, no networks had degree centralizations that exceeded 0.5 at six or twelve months. As centralizations may vary from 0 to 1, 0.5 can be considered as the threshold at which networks begin to have a dominant, central organization within the community; while a value of 1 would indicate a single central actor in a community. Small degree centralization scores also support the absence of a single dominant organization being more active within networks. While previous theories (Balcik et al. 2010) argue that networks tend to become more centralized over time following a disaster, a mean centralization decrease of 27% was observed in networks over time. This indicates that networks may have been more centralized during the early recovery effort phase, but that they tend to become more decentralized over time. This led to relatively few organizations dictating construction guidelines at approximately six months and collective networks trying to enforce these standards at twelve months, resulting in weak adoption of standards. A summary of the normalized network centralizations is presented in Figure 2.
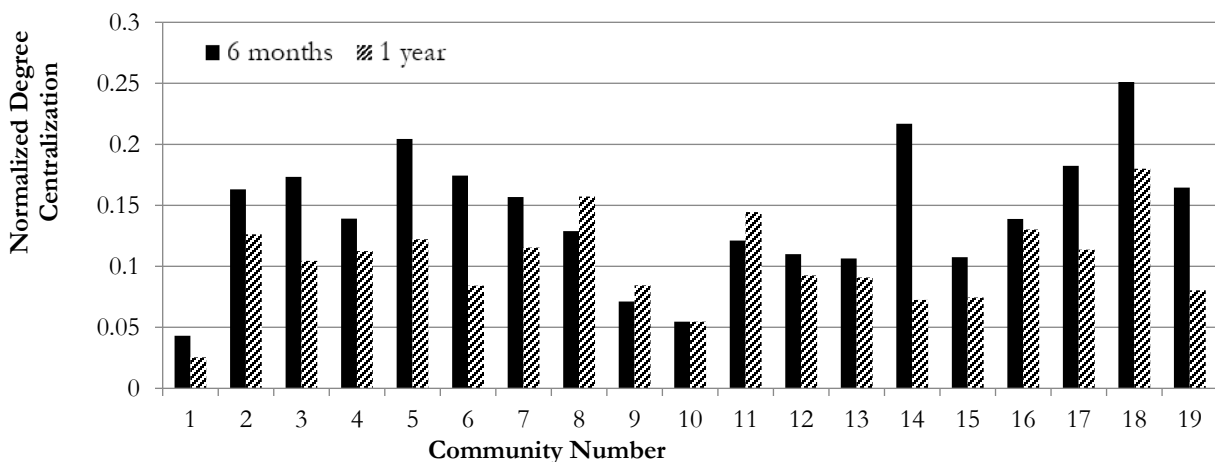

Figure 2: Normalized Degree Centralization of Combined Resource Networks

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Several communities are exceptions to the primary trend of decentralization. For instance, community 1 had a resource degree centralization that was very low at both time periods. While this community had a number of shelter programs, all actors participated in a similar way, and no one actor took a central, leading role. On the other hand, in community 14, the degree centralization is very high at six months compared to other networks. As a relocation site, one primary NGO took a central role in infrastructure delivery where there was an absence of other organizations. The other communities that were relocation sites included numbers 7, 11 and 17. While a comparison of relocation and in-situ sites is an important topic in recovery, it is beyond the scope of this study to compare these differences.

Change of Central Organizations
To determine if the central organizational actors remained the same or changed over time, we analyzed which organizations were central at each period of time. From the 309 programs carried out by organizations within the 19 communities, only 54 programs could be considered as controlled by a central organization. These 54 central programs were carried out by 21 of the 86 identified organizations. This result is surprisingly low as it implies that only 21% of organizations play a central role in coordination practice. Of the 54 different central programs, only 5 of them (9%) are occupied by the same organization at six months and twelve months. This reaffirms the dynamic nature of networks and that key positions evolve over time. For example, in community 17, the central organizational actor was active in only this community but had programs in multiple sectors, including shelter, WASH, protection and disaster risk reduction (DRR). The organization focused its efforts on cross-sector infrastructure programming and placed resources toward embedding themselves into this one community. As a result, they maintained their centrality over time within the community.
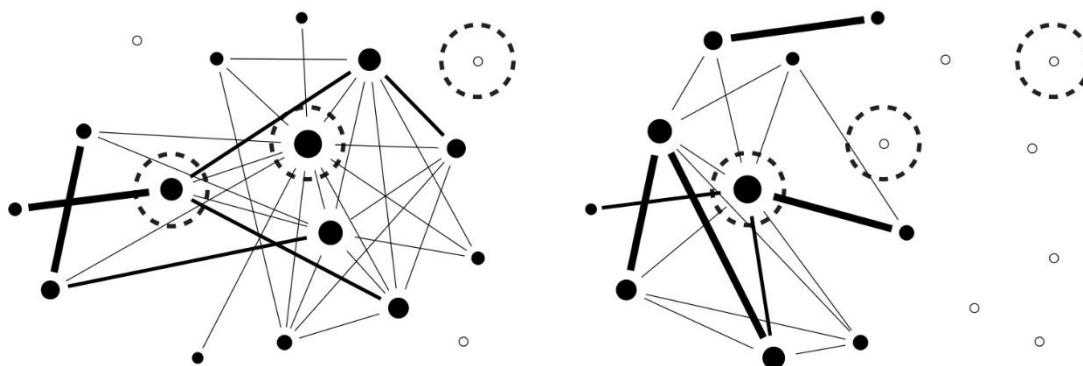

Figure 3: Central Actor Shifts in Resource Coordination Networks

Returning to our previous analysis of government agencies and UNOCHA, community 11 highlights trends seen in these shifts, shown in Figure 3. A total of 17 organizations were involved in this community. DSWD is highlighted on the left, UNOCHA in the center and NHA on the right. In this instance we can see that there was a shift of the network from UNOCHA as the primary central actor at six months to DSWD at twelve months, resulting in a profound shift in network ties. At six months, network density is 0.235, while at twelve months it drops to 0.132, illustrating the impact of central actor changes. Moreover, normalized degree centralization is 0.121 at six months and increases to 0.145 at twelve months. These networks clearly show how the coordination core moves in the face of changing central actors. This change was likely driven by the departure of the cluster system at twelve months.

Disconnected Networks Over Time

The mean density of networks at six months was 0.220, which implies that on average, 22% of possible ties exist. The maximum density observed was 0.319 At twelve months, the mean density of networks decreased to 0.070. The densities started low at six months and tended to decrease over time. Here we will only discuss the combined resource networks, however individual resource networks were observed to follow similar trends. A density decrease might come from two possible factors: (1) a decrease of the number of ties, or (2) increase of the number of isolated actors, which implies an increase of the number of potential ties. The number of resources coordinated had a mean density decrease of 66%, although a decrease of more than 85 % is seen in three communities. The origin of the decrease is due to both a 66% decrease in the number of ties and due to an increase of the number of isolated actors, on average 39%, in communities.

Findings show that coordination networks become more decentralized over time. In general, this is seen as a positive trait, as the removal of a central actor can be detrimental to collective decision-making. However, the studied coordination networks show that the departure of key organizations, even ones that do not appear central, can have a profound impact on continued communication, and potentially, the long-term resilience and sustainability of the recovery effort. This was observed in the dramatic drop in network densities across all communities. Among the organizations that left the recovery effort shortly before twelve months, the most significant was the departure of the cluster coordination bodies. These entities provided institutional support for coordination efforts and established norms for organizations to engage in resource sharing at early stages of the recovery effort. In particular, UNOCHA, whose mandate is to support humanitarian coordination, departed shortly before the twelve-month period studied. This is significant because of the twenty communities studied, all had significant ongoing infrastructure reconstruction. UNOCHA was involved in all the communities, and although they had a central role in only three of them, their mean degree centrality was higher than the average organization. Specifically, UNOCHA's mean degree centrality is 0.534 at six months, while the average was only 0.346. At twelve months, UNOCHA's mean degree centrality dropped to zero while the mean degree centrality dropped to 0.257. As this entity is a central organization in sharing information as a resource, and as information was the most common resource shared, its departure stressed communication avenues and left gaps in networks. Our analysis suggested that UNOCHA's withdrawal is one of the reasons for the decrease of activity in information sharing.
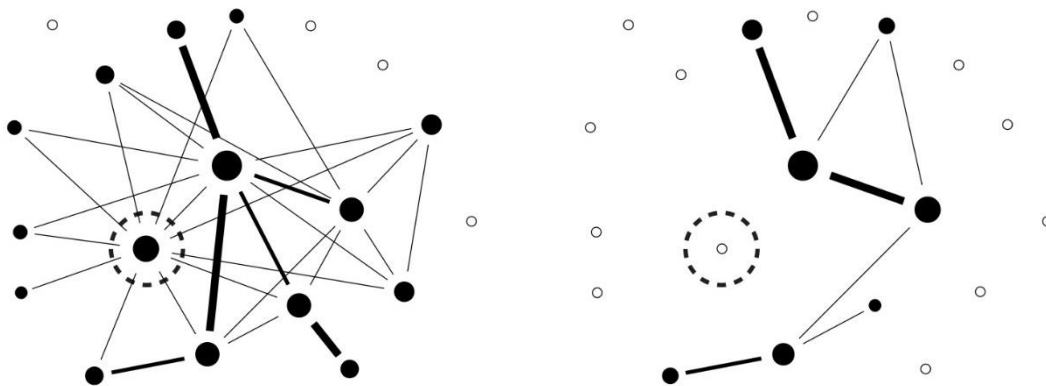

Figure 4: Impact of Institutional Support in Resource Coordination Networks

As illustrated by the combined resource network from the community 6 shown in Figure 4, the departure of UNOCHA changed the landscape for inter-organizational resource coordination. It is clearly observable that, after the withdrawal of UNOCHA, networks lost significant connections. Densities of these networks are also heavily impacted by UNOCHA's leaving. This density drop equates to a 75% loss in connections after six months. In particular, this provides a strong argument for the need to allocate financial resources towards institutional mechanisms that support coordination. Despite the fact that initial planning had been completed, significant design and construction activities for infrastructure were still in progress during the twelve-month observation. One NGO worker said, *"[Now] we just go directly to where there is a concern, unlike before that there was a forum."* The result was a transition from proactive prevention of clashes between work tasks to one that was reactive. In summary, our analysis shows that the departure of the UNOCHA and the cluster system decreased coordination within communities. Thus, while there have been concerted efforts to increase grassroots coordination efforts and decrease control within humanitarian organizations, this analysis suggests that some forms of formalized coordination and control are still necessary to enhance coordination between organizations.

Program Duration and Organizational Presence

While we have shown that networks become more decentralized over time and coordination tapers off, our analysis kept the number of organizations consistent at six and twelve months. As a result, it is important that we briefly discuss and examine the length of organizational programs in communities. Our analysis showed a 39% decrease in connected organizations, implying that organizations had either left, stopped coordinating, or were present but terminated communication. Isolated, or non-connected, organizations who were known to be active in a community through site observations, but who did not take part in coordination efforts, represent 10% of the isolated organizations at six months, and 3.5% at twelve months. Further, 10% of isolated programs started before six months and were completed prior to twelve months. This means that organizations carrying out these programs were considered as isolated actors at twelve months, even though their programming was complete by the second observation period. Finally, 4% of programs started after six months. These organizations are still included in the six month networks, but were not yet present in communities. These numbers highlight that most organizations were involved for the entirety of the twelve-month period studied. Analysis shows that 31% of organizations who remain present in community recovery efforts become isolated over time in the coordination networks. This confirms that organizations which decide to remain present in communities tend to terminate coordination efforts over time, which raises concerns as recovery progresses.

Authority Shift

One of the major themes that emerged from our analysis was the impact of staffing contracts on network changes. Among the 309 projects carried out in communities, 54% were run by organizations staffed by expatriates at six months. At twelve months, this percentage decreased to 30%. Organizations were considered as having expatriate staff if the origin of more than 50% of their workforce was identified as being non-local. When related to network density, analysis shows that communities with expatriate staff tend to have the densest networks at six months and face a larger decrease in density over time. On the other hand, these communities followed network trends similar to other communities when examining degree centralizations. It suggests that a shift from expatriates to locals does not impact the homogeneity of networks, but instead, impacts their densities. Our analysis further shows that at six months, the origin of the workforce does not impact their position in the network. In other words, actor centralities were not found to relate to network position of an

organization. The major shift, however, is that at twelve months, locally-staffed organizations become more central actors when compared to expatriate-staffed organizations.

Authority shift impacted coordination, as at six months, expatriate staff were seen as more active at sharing resources and communicating more frequently, while at twelve months, the balance changed, and locally staffed organizations were more active. On-site observations further demonstrated the disconnect resulting from staffing changes as it was not uncommon that staff at twelve months were unaware of their organization's past operations in a community. This gap in transitioning staff is one factor we believe explains the change of central organizations in network coordination over time. New staff need to recreate ties that may have been lost with other organizations and these connections may have been informal or undocumented. This transition supports why only 9% of central actors remained the same. This finding echoes calls from other network studies in humanitarian contexts to integrate local partners earlier in disaster recovery efforts (Holguín-Veras et al. 2012). In summary, we have discussed key changes in networks as well as potential causes for this shifts in order to answer our third research question which asked how post-disaster inter-organizational networks change during early recovery.

Validity Checks

Our validity checks support that our approach to qualitatively constructing networks was suitable. In comparing researcher generated networks with the sample of organizational surveys, we found disagreement ranging, on average, from 3% to 18% across communities. A summary of comparisons for each resource is presented in Table 4. From these results, it becomes obvious that the survey responses align well with the qualitatively constructed matrices based upon observation and interviews as the percentages of disagreement are low. The researcher constructed ties and organizational surveys tend to align more at twelve months than at six months. This may be because organizations were asked to report their six month activities at the same time they were asked about twelve month activities within the survey questionnaires, requiring them to retroactively remember their earlier activities. In addition, as mentioned earlier, the turnover of organization staff may have led to misinformed organizational responses. When analyzing survey responses, it appears that organizations mentioned higher rates of resource coordination than the researchers noticed on site. Despite limited disagreement between sources, however, both sources showed similar overall trends in resource coordination. The primary location of disagreement related to information resources, which may stem from one-time communication occurrences by an organization respondent, which was not observed by the researchers.

Table 4: Data Validation

	Material		Human		Information		Finance	
	6 months	1 year	6 months	1 year	6 months	1 year	6 months	1 year
Mean Percentage of Disagreement	6%	4%	4%	3%	18%	18%	7%	5%
Standard Deviation	9%	6%	7%	7%	13 %	20%	7%	6%

Finally, discrepancies were observed within survey responses. Among them were discrepancies linked to resource sharing, as some respondents reported coordinating resources with an organization during a period when they had indicated earlier in the survey that the coordination with the organization had

already ended. These later responses were removed from the analysis on the basis that the initial question asked whether coordination still existed.

Limitations

While the researchers spent extensive time in the field collecting data on the presence of organizations in communities, there is still a potential that organizations were missed and thus excluded from networks. The absence of these organizations would result in incomplete networks, however, due to the multiple methods of data collection, it is unlikely that these entities played a significant role in reconstruction. Additionally, we intentionally selected to bound our networks at the community level. In reality, coordination extends beyond these limits and these social boundaries are fuzzy. Given that organizations themselves chose to define project limits at the community level we feel that our networks represent a practical basis for understanding coordination.

Another limitation was the selection of six and twelve months as the points in time to study coordination. Recovery efforts are inherently dynamic and coordination changes follow this pattern. However, these points in time allowed us to investigate two significant stages: (1) after the transition from emergency services towards long-term provision service at six months and (2) after the transition out of cluster coordination at twelve months. The study of cluster departure was also based on the network presence, and absence, of UNOCHA. We used this organization as a proxy to study cluster impact as all reporting was handled through UNOCHA and individual clusters are better represented as networks rather than nodes within organizational networks. Further, our validation data at six months was collected through retrospective accounts from survey respondents. The lack of real time collection introduces potential error, but also allowed the researchers to better reflect on changes that occurred when creating networks.

Lastly, our results are only from one hazard event and should be validated through future recovery efforts. The Philippines is a unique case given the large number of typhoons that occur annually. Despite the large awareness of disaster risk reduction, the international response that was elicited exhibits similarities seen in coordination to other subsequent responses.

Conclusions

In conclusion, our findings showed that information was the most frequently coordinated resource, followed by material, financial and human resources, answering our first research question. The documentation of coordination networks for different resources at two periods following a disaster helps us to better understand the types of resources that are coordinated more or less frequently to strategically identify coordination inefficiencies. For instance, human resources were coordinated least frequently, and were a source of tension within network structures, however, coordination of trained labor is frequently cited as important for building community resilience (Amaratunga and Ginige 2011). Our findings also highlighted the important role of government agencies for facilitating long-term coordination within communities and the detrimental shift in coordination when centralized control is removed. This answered our second question of who are the central actors in coordination networks, supporting past work that has showed government agencies are most commonly the central players (Kapucu et al. 2010b). Our qualitative data portrayed a different picture of these connections, however, showing that, in many cases, these relationships were weak in early recovery phases but flourished in later stages.

One criticism of social network analysis presented in literature is its static nature, only depicting social structures at one point of time (Abbasi and Kapucu 2012). Our third and final research question

focused on the analysis of multiple coordination time periods, answering calls to examine how coordination networks change and evolve over time (Abbasi and Kapucu 2015). Our findings showed that networks become more decentralized over time, in stark contrast to past theory of emergency management which showed centralization and consolidation of networks. We hypothesize that this is a result of the time scales being investigated and encourage further study in this area. Methodologically, we have implemented and validated the use of qualitative data to construct networks. This presents new opportunities to use social network analysis as a means to study medium sized social groups. In the past, survey methods have rendered these networks difficult to examine given response rates and incomplete sampling of network actors. By using third party observation, greater consistency of link evaluations can be achieved without sacrificing the accuracy of these ties.

Practically, we provided recommendations to organizations to enhance coordination and infrastructure delivery following disasters. In particular, our network analysis has shown the detrimental effects of short term expatriate contracts. Qualitatively, many NGO workers openly discussed their frustration with the current status quo and resources provided to the transitional period following emergency phases. Donors, in particular, should consider allocating sufficient time and funding to ensure that as local staff are hired by organizations, that resources are in place to ensure an efficient shift. It was observed that organizations with longer-term staff contracts had greater continuity in coordination. Extending traditional six month contracts to twelve months could also assist in bolstering coordination of aid organizations. In addition, our findings demonstrate that organizations seeking to gain access to information should seek out involvement in cluster coordination during early months of recovery and connect with government agencies.

Future Work

We have taken a first step towards understanding coordination networks that form at the community level and compared these networks across two points in time. To our knowledge, we conducted the first social network analysis of community level coordination networks following a hazard event. These coordination structures can be analyzed in the future with short and long-term recovery outcomes to determine the influence that coordination practice and structure had on resilience outcomes. Next steps should also continue to explore coordination at the community level through social network analysis, as we focused explicitly on *organizational* networks. New research should explore how these networks are similar to or contrast regional and national networks. There is also a need to explore individual networks to understand how community members interact and coordinate resources in recovery. Additional time periods can also assist our understanding of how networks evolve during different phases of reconstruction. Finally, it is essential that future research begin to link coordination processes to resilience outcomes of reconstruction efforts.

References

Abbasi, A., and Kapucu, N. (2012). "Structural Dynamics of Organizations during the Evolution of Interorganizational Networks in Disaster Response." *Journal of Homeland Security and Emergency Management*, 9(1).
Abbasi, A., and Kapucu, N. (2015). "A longitudinal study of evolving networks in response to natural disaster." *Computational and Mathematical Organization Theory*.
Amaratunga, D., and Ginige, K. (2011). "Capacity Development for Post-Disaster Reconstruction of the Built Environment." *Post-Disaster Reconstruction of the Built Environment: Rebuilding for Resilience*, John Wiley & Sons, Chichester, UK, 13–29.

Balcik, B., Beamon, B. M., Krejci, C. C., Muramatsu, K. M., and Ramirez, M. (2010). "Coordination in humanitarian relief chains: Practices, challenges and opportunities." *International Journal of Production Economics*, 126(1), 22–34.

Berke, P., Kartez, J., and Wenger, D. (1993). "Recovery after Disaster: Achieving Sustainable Development, Mitigation and Equity." *Disasters*, 17(2).

Center for Excellence in Disaster Management and Humanitarian Assistance. (2014). *Lessons from Civil-Military Disaster Management and Humanitarian Response to Typhoon Haiyan (Yolanda)*. Center for Excellence in Disaster Management & Humanitarian Assistance, Pearl Harbor, Hawaii.

Chen, R., Sharman, R., and Rao, R. (2008). "Coordination in Emergency Response Management." *Communications of the ACM*, 51(5), 66–73.

Comfort, L. K. (2004). "Coordination in Rapidly Evolving Disaster Response Systems: The Role of Information." *American Behavioral Scientist*, 48(3), 295–313.

Drabek, T. (2002). "Emergent Phenomena and Multiorganizational Coordination in Disasters: Lessons from the Research Literature." *International Journal of Mass Emergencies and Disasters*, 20(2), 197–224.

Drabek, T. E. (1985). "Managing the Emergency Response." *Public Administration Review*, 45, 85.

Drabek, T. E. (2007). "Community processes: coordination." *Handbook of Disaster Research*, Springer, New York, 217–233.

El-Sheikh, A., and Pryke, S. D. (2010). "Network gaps and project success." *Construction Management and Economics*, 28(12), 1205–1217.

Faraj, S., and Xiao, Y. (2006). "Coordination in Fast Response Organizations." *Management Science*, 52(8), 1155–1169.

Freeman, L. C. (1978). "Centrality in social networks conceptual clarification." *Social Networks*, 1(3), 215–239.

Frimpong, Y., Oluwoye, J., and Crawford, L. (2003). "Causes of delay and cost overruns in construction of groundwater projects in a developing countries; Ghana as a case study." *International Journal of Project Management*, 21(5), 321–326.

Holguín-Veras, J., Jaller, M., and Wachtendorf, T. (2012). "Comparative performance of alternative humanitarian logistic structures after the Port-au-Prince earthquake: ACEs, PIEs, and CANs." *Transportation Research Part A: Policy and Practice*, 46(10), 1623–1640.

Ingirige, B. (2016). "Theorizing construction industry practice within a disaster risk reduction setting: is it a panacea or an illusion?" *Construction Management and Economics*, 1–16.

Jahre, M., and Jensen, L. (2010). "Coordination in humanitarian logistics through clusters." *International Journal of Physical Distribution & Logistics Management*, (P. Tatham, ed.), 40(8/9), 657–674.

Jarzabkowski, P. A., Lê, J. K., and Feldman, M. S. (2012). "Toward a Theory of Coordinating: Creating Coordinating Mechanisms in Practice." *Organization Science*, 23(4), 907–927.

Jordan, E., Javernick-Will, A., and Amadei, B. (2015). "Post-disaster reconstruction: lessons from Nagapattinam district, India." *Development in Practice*, 25(4), 518–534.

Jordan, E., Javernick-Will, A., and Tierney, K. (2016). "Post-tsunami recovery in Tamil Nadu, India: combined social and infrastructural outcomes." *Natural Hazards*.

Jung, K. (2013). *Quick Response Report: Community Resiliency and Emergency Management Networks Following the 2012 Korean Typhoons*. Natural Hazards Center.

Kapucu, N. (2005). "Interorganizational coordination in dynamic context: Networks in emergency response management." *Connections*, 26(2), 33–48.

Kapucu, N. (2006). "Interagency Communication Networks During Emergencies: Boundary Spanners in Multiagency Coordination." *The American Review of Public Administration*, 36(2), 207–225.

Kapucu, N., Arslan, T., and Collins, M. L. (2010a). "Examining Intergovernmental and Interorganizational Response to Catastrophic Disasters: Toward a Network-Centered Approach." *Administration & Society*, 42(2), 222–247.

Kapucu, N., Arslan, T., and Demiroz, F. (2010b). "Collaborative emergency management and national emergency management network." *Disaster Prevention and Management*, 19(4), 452–468.

Kapucu, N., Yuldashev, F., and Feldheim, M. A. (2011). "Nonprofit organizations in disaster response and management: A network analysis." *European Journal of Economic and Political Studies*, 4(1), 83–112.

Kellogg, K. C., Orlikowski, W. J., and Yates, J. (2006). "Life in the trading zone: Structuring coordination across boundaries in postbureaucratic organizations." *Organization Science*, 17(1), 22–44.

Mileti, D. (1999). *Disasters by Design: A Reassessment of Natural Hazards in the United States*. National Academies Press.

Montoya-Weiss, M. M., Massey, A. P., and Song, M. (2001). "Getting It Together: Temporal Coordination and Conflict Management in Global Virtual Teams." *Academy of Management Journal*, 44(6), 1251–1262.

National Economic and Development Authority. (2013). *Reconstruction Assistance for Yolanda*. National Economic and Development Authority, Pasig City, Philippines.

Neeraj Jha, K., and Misra, S. (2007). "Ranking and classification of construction coordination activities in Indian projects." *Construction Management and Economics*, 25(4), 409–421.

Newman, M. E. (2003). "The structure and function of complex networks." *Society for Industrial and Applied Mathematics Review*, 45(2), 167–256.

Nolte, I. M., Martin, E. C., and Boenigk, S. (2012). "Cross-Sectoral Coordination of Disaster Relief." *Public Management Review*, 14(6), 707–730.

O'Brien, G., O'Keefe, P., Gadema, Z., and Swords, J. (2010). "Approaching disaster management through social learning." *Disaster Prevention and Management*, 19(4), 498–508.

Okhuysen, G. A., and Bechky, B. A. (2009). "Coordination in Organizations: An Integrative Perspective." *The Academy of Management Annals*, 3(1), 463–502.

Powell, P. J. (2011). "Post-disaster reconstruction: A current analysis of Gujarat's response after the 2001 earthquake." *Environmental Hazards*, 10(3–4), 279–292.

Pryke, S. (2012). *Social Network Analysis in Construction*. John Wiley & Sons, Chichester, UK.

Pryke, S. D. (2004). "Analysing construction project coalitions: exploring the application of social network analysis." *Construction Management and Economics*, 22(8), 787–797.

Pryke, S. D. (2005). "Towards a social network theory of project governance." *Construction Management and Economics*, 23(9), 927–939.

Quarantelli, E. L. (1997). "Ten criteria for evaluating the management of community disasters." *Disasters*, 21(1), 39–56.

Ritchie, L. A., and Tierney, K. (2011). "Temporary housing planning and early implementation in the 12 January 2010 Haiti Earthquake." *Earthquake Spectra*, 27(S1), S487–S507.

Salmon, P., Stanton, N., Jenkins, D., and Walker, G. (2011). "Coordination during multi-agency emergency response: issues and solutions." *Disaster Prevention and Management*, 20(2), 140–158.

Scott, J. (2012). *Social Network Analysis*. SAGE, London, UK.

Smith, G. P., and Wenger, D. (2006). "Sustainable Disaster Recovery: Operationalizing An Existing Agenda." *Handbook of Disaster Research*, Springer, New York, NY, 234–257.

Steets, J., Grünewald, F., Binder, A., De Geoffroy, V., Kauffmann, D., Krüger, S., Meier, C., and Sokpoh, B. (2010). *Cluster Approach Evaluation 2: Synthesis Report*. Global Public Policy Institute and Groupe Urgence Réhabilitation Développement, Berlin, Germany, 162.

Topper, C. M., and Carley, K. M. (1999). "A structural perspective on the emergence of network organizations." *The Journal of Mathematical Sociology*, 24(1), 67–96.

Varda, D. M., Forgette, R., Banks, D., and Contractor, N. (2009). "Social Network Methodology in the Study of Disasters: Issues and Insights Prompted by Post-Katrina Research." *Population Research and Policy Review*, 28(1), 11–29.

Wasserman, S., and Faust, K. (1994). *Social Network Analysis: Methods and Applications*. Cambridge University Press, Cambridge, UK.

Willis, K. (2011). *Theories and Practices of Development*. Taylor & Francis.