

## 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 19 communities in the Philippines following Super Typhoon Haiyan, at 6 and 12 months post-disaster. To build these networks, we analysed 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 suggest 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.

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## Introduction

Disaster recovery lies beyond the capacity of single organizations and requires coordinated efforts (Balcik *et al.* 2010, Kapucu, Arslan, Collins 2010). 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 that 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 among these organizations can 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 11 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 and 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 programmes that centre 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 (SNA). SNA also enabled us to identify which actors take on central roles in coordination activities. To answer the third question, we analysed and compared networks within the same communities at two different time periods during the recovery process, the first at 6 months post-disaster and the second at 12 months post-disaster. Our questions focused on early recovery efforts within the first 12 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 towards 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 (Quarantelli 1997, Jordan *et al.* 2016). 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 analyse 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, Arslan, Collins 2010, 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 analyse 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 among 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. labour workforce), *information* (e.g. expertise, contacts) and *financial* (e.g. joint funding projects) resources (Frimpong *et al.* 2003, Chen *et al.* 2008, 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 behaviour 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 by the International Federation of the Red Cross (IFRC) and United Nations High Commissioner for Refugees (UNHCR). There is a dearth of research that has analysed coordination under the cluster system. Research is needed to identify how the cluster system has influenced resource coordination among 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 developing countries. Past shortcomings of government managed reconstruction programmes 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, Arslan, Demiroz 2010). 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, Arslan, Collins 2010), 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

SNA is a methodology used to analyse 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 SNA 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 (Wasserman and Faust 1994, Pryke 2012). From multiple available metrics, researchers can analyse 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. SNA 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 analysed 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.

### SNA in disaster coordination

Abbasi and Kapucu (2012) describe SNA as “a theoretical lens and analytical tool for discovering the patterns of communications and its dynamics in crisis situations”. Although SNA is not a new methodology, it is new in disaster research (Varda *et al.* 2009). As stated by Kapucu *et al.* (2011), SNA “offers a unique opportunity to study the complex nature of disaster response”. Presently, a limited number of studies have used SNA to understand post-disaster coordination networks, focusing on interactions among public, private and non-profit organizations following 9/11 (Kapucu 2005), inter-governmental and inter-organizational response to Hurricane Katrina (Kapucu, Arslan, Collins 2010), evolving organizational response to the cycle of Floridian hurricanes (Kapucu, Arslan, Demiroz 2010), 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 SNA can be a useful tool in modeling these interactions.

While SNA reduces and quantifies social structures, it also makes them visible and comparable across cases (Pryke 2004, 2005). Moreover, by mapping a visualized

network, SNA 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 SNA 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 SNA, 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 SNA as a means to operationalize and compare coordination structures for four different types of resources – *material, human, information and financial* – across 19 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 8 November 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, 9 of the 17 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 (Centre 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 programmes, such as livelihood assistance and social development. Examples of supplementary livelihood and social programmes 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 programmes. We define a programme here as a service delivered by a single organization. For example, a WASH programme 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 were 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 6 and 12 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 programmes, 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 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 SNA 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 SNA 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. labour 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 6 and 12 months. Multiple subsequent passes were completed after reviewing collected qualitative data. This generated 4 resource network matrices for each community at 6 months and 4 resource network matrices at 12 months that described coordination structures. An additional network was compiled for each time period, at 6 and 12 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 were 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 programmes 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 6 and 12 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. 20 of the 86 organizations responded to the survey, resulting in a 23% response rate. As these responses covered 52 of the 309 identified programmes, it confirms that collecting SNA 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) programme, 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, SNA 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, Arslan, Collins (2010), 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 analysed 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 was repeated for every answer received from each organization survey, for each resource, at 6 and 12 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, 6 and 12 months after the disaster.

### Resource coordination

Based on the different types of resources analysed (material, human, information and financial), SNA 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 6 and 12 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 is provided in Table 2.

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,

**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

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 labour and it was common to see wage wars between organizations for carpenters and masons. For example, one NGO project manager said,

When the foreign NGOs come in they would up the price for labour 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 analysed 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 programme 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 12 than 6 months. Finally, human resources, was 29% lower at 12 months when compared to 6 months. This serves to answer our first research question which asked what resources are most frequently coordinated in post-disaster inter-organizational networks.

Analysing 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 from a lack of coordination, including price escalation and “poaching” trained labour 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 12 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 programmes analysed, 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 programmes among communities. This suggests that local organizations tend to be involved in communities more than international organizations that may focus their attention on a smaller number of communities.

Network metrics provide additional support for local organizations' important role in coordination. At 6 months, local organizations had a mean degree centrality of 0.297 in comparison to 0.267 for international organizations. At 12 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 programme 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 behaviours in coordination practice. DSWD was active in all of the studied communities and had a recurrent central role, while the 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 6 months, and in 89% of communities at 12 months. Further, in all but 5 of the communities, DSWD was the most central actor at both 6 and 12 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 analysed. 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

**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

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.

While governmental agencies were central actors at 6 months, an interesting trend emerged in their network role at 12 months – they were commonly positioned between two isolated sub-groups in the networks. Thus, despite limited authority at 6 months, these early connections led to their continued role to link organizations at 12 months. To demonstrate this, we have illustrated the community network of organizations for case 17 at 6 and 12 months in Figure 1. DSWD, circled, is central at 6 months and has a large number of connections, having a degree centrality of 0.500. At 12 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 12 months, 4 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 governmental organizations play an important role in long-term linkages.

It is worth noting that DSWD was present in every community, therefore, the impact of limited government involvement cannot be discussed. By analysing densities of networks, however, it appears that communities where DSWD was not central have a higher than average density at 6 months, and a lower than average density at 12 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, Arslan, Demiroz 2010, Powell 2011), this analysis suggests that governmental agencies do have an essential role in

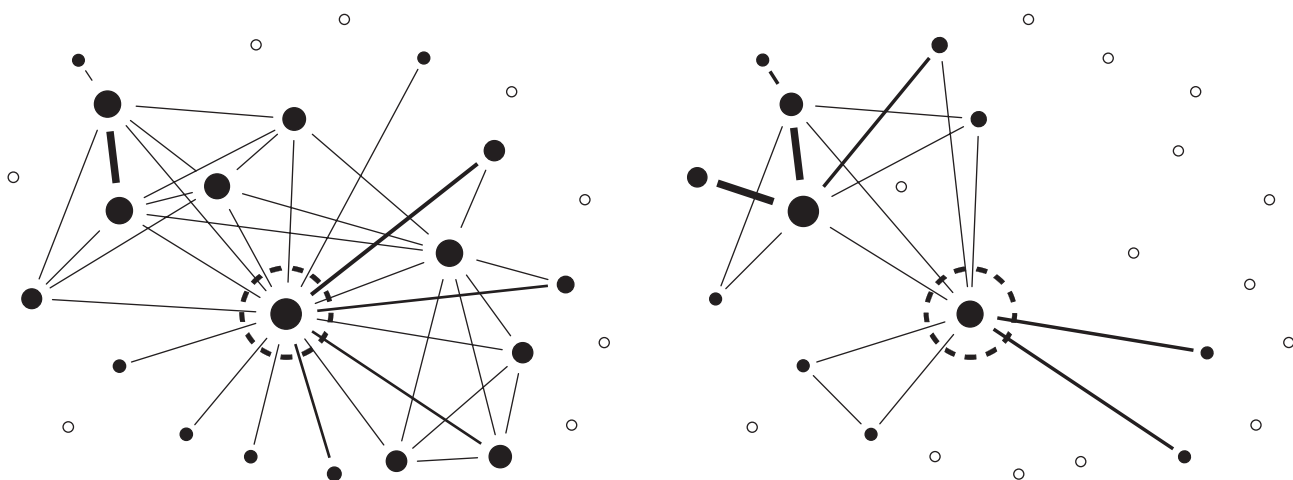
long-term resource coordination. It also implies that while the lack of a central governmental agency can be advantageous in the short-term, as it is associated with additional connections between potential actors, this lack of central government agency can be detrimental to long-term coordination when 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 6 months and, conversely, local organizations have higher centralities than international organizations at 12 months, answering our second research question.

### Network evolution

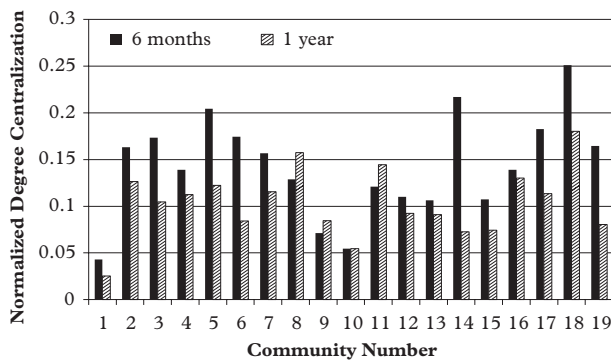
Based upon the longitudinal network analysis, we present results for network evolution through the following metrics: network centralization, actor centralities, densities and number of connected organizations. The mean actor centrality of the combined resource networks was found to decrease by 26% over time. We also analysed 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 6 or 12 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



**Figure 1.** Impact of government agencies on coordination, 6 months post-disaster (left) and 12 months post-disaster (right)



**Figure 2.** Normalized degree centralization of combined resource networks

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 6 months and collective networks trying to enforce these standards at 12 months, resulting in weak adoption of standards. A summary of the normalized network centralizations is presented in Figure 2.

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 programmes, 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 6 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 analysed which organizations were central at each period of time. From the 309 programmes carried out by organizations within the 19 communities, only 54 programmes could be considered as controlled by a central organization. These 54 central programmes 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 programmes, only 5

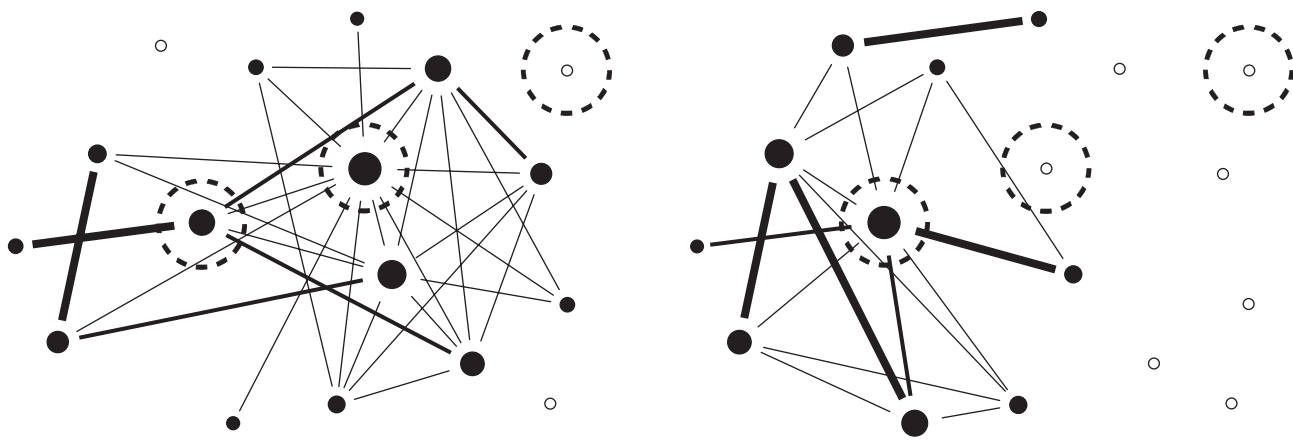
of them (9%) are occupied by the same organization at 6 months and 12 months. This reaffirms the dynamic nature of networks and that key positions evolve over time. For example, in community 17, the central organizational actor was active in only this community but had programmes in multiple sectors, including shelter, WASH, protection and disaster risk reduction (DRR). The organization focused its efforts on cross-sector infrastructure programming and placed resources towards embedding themselves into this one community. As a result, they maintained their centrality over time within the community.

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 centre 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 6 months to DSWD at 12 months, resulting in a profound shift in network ties. At 6 months, network density is 0.235, while at 12 months it drops to 0.132, illustrating the impact of central actor changes. Moreover, normalized degree centralization is 0.121 at 6 months and increases to 0.145 at 12 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 12 months.

### Disconnected networks over time

The mean density of networks at 6 months was 0.220, which implies that on average, 22% of possible ties exist. The maximum density observed was 0.319. At 12 months, the mean density of networks decreased to 0.070. The densities started low at 6 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 in the number of ties, or (2) increase in the number of isolated actors, which implies an increase in 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 in 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,

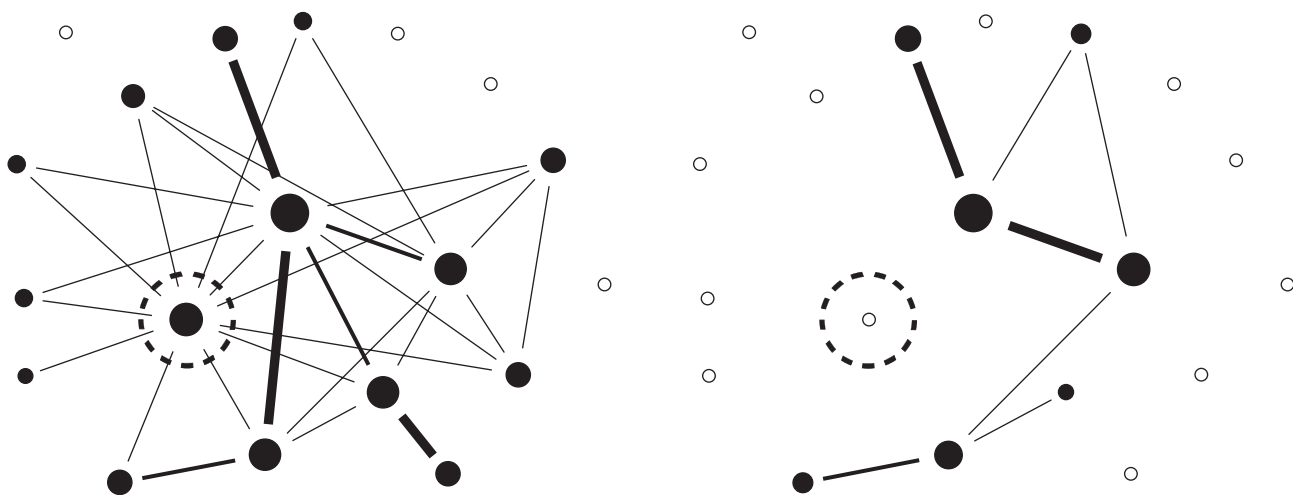


**Figure 3.** Central actor shifts in resource coordination networks, 6 months post-disaster (left) and 12 months post-disaster (right)

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 12 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 12-month period studied. This is significant because of the 20 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 6 months, while the average was only 0.346. At 12 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.

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 6 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



**Figure 4.** Impact of institutional support in resource coordination networks, 6 months post-disaster (left) and 12 months post-disaster (right)



12-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.

### **Programme 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 6 and 12 months. As a result, it is important that we briefly discuss and examine the length of organizational programmes 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 6 months, and 3.5% at 12 months. Further, 10% of isolated programmes started before 6 months and were completed prior to 12 months. This means that organizations carrying out these programmes were considered as isolated actors at 12 months, even though their programming was complete by the second observation period. Finally, 4% of programmes 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 12-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 12 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 6 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 6 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 12 months, locally staffed organizations become more central actors when compared to expatriate staffed organizations.

Authority shift impacted coordination, as at 6 months, expatriate staff were seen as more active at sharing resources and communicating more frequently, while at 12 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 12 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 12 months than at 6 months. This may be because

**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

organizations were asked to report their 6-month activities at the same time they were asked about 12-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 analysing 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.

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 6 and 12 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 6 months and (2) after the transition out of cluster coordination at 12 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 6 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 DRR, 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 labour is frequently cited as important for building community resilience (Seneviratne 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, Arslan, Demiroz 2010). 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 SNA 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 SNA 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 6-month contracts to 12 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 SNA of community-level coordination networks following a hazard event. These coordination structures can be analysed 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 SNA, 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.

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