**Social Network Analysis in Natural Disaster Response and Recovery**

*Research paper for Social Network Analysis Course*

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# Contents



# Abstract

This paper investigates the role of Social Network Analysis (SNA) in exploring the social dynamics of disaster response and recovery. It presents a structured analysis across the various phases of disasters—pre-, during, and post-event—drawing on concrete examples from the literature review. The case studies include the 2016 Louisiana floods, Hurricane Harvey in 2017, the Aila cyclone of 2009, and the 2017 Sri Lanka floods.

SNA is employed to map the social ties and to measure the impact of these connections on community resilience. The study reveals how network structures evolve: they are dense before disasters, become disrupted during the event, and tend to reorganize and solidify as the community recovers. The paper concludes by articulating the significance of SNA in providing actionable insights for disaster preparedness and in aiding communities to rebuild and fortify their social infrastructure for future resilience.

# 1. Introduction

## 1.1. The Importance of Social Network Analysis in Disaster Response and Recovery

Social Network Analysis is a methodological approach to understanding the structures of relationships and flows between various entities, which could be individuals, groups, or organizations. In the context of disaster management, SNA helps to map out and analyze the social connections and networks that come into play during the preparation, response, and recovery phases. It sheds light on the patterns and dynamics of communication, support, and resource sharing that are essential for a community to bounce back from adversity.

When disaster strikes, the visible and invisible ties within a community can mean the difference between swift recovery and prolonged hardship. SNA uncovers these ties, providing insights into the informal networks that spring into action when formal systems may be struggling to cope. By mapping these networks, emergency responders can identify key nodes—individuals or organizations that are critical in the dissemination of information and resources.

## 1.2. Harnessing Social Capital for Community Resilience in Disasters

*„We are all in the same boat"* [1]

In disaster response and recovery, the strength and structure of community networks can significantly impact resilience and the efficacy of recovery efforts. Central to understanding these network dynamics is the concept of homophily, the tendency for individuals to connect with others who are similar to themselves in certain attributes like age, race, or socioeconomic status. This natural gravitation towards similarity can create strong, cohesive networks, known as homophilous networks, which are beneficial in fostering quick coordination and mutual understanding during immediate disaster responses.

However, while homophily can strengthen internal support within a group, it can also lead to insularity, limiting access to a broader range of resources and information that are often critical in the recovery phase. This is where bridging social capital becomes essential. Bridging social capital connects these homogenous groups to a wider, more diverse network, introducing a variety of resources, information, and support systems. By linking different groups, bridging social capital breaks through the echo chambers created by homophily, thereby enhancing a community's adaptive capacity and resilience.

Structural diversity within networks, integrating homophilous (bonding) and heterogeneous (bridging) ties, plays a crucial role in disaster management. Such diversity not only aids in immediate disaster response by leveraging the quick mobilization characteristic of homophilous networks but also supports long-term recovery and adaptation by connecting these networks to external resources and new perspectives. Thus, a balanced approach that harnesses both homophily for immediate action and bridging for sustainable recovery can significantly enhance community resilience in the face of natural disasters. This strategy enables communities to manage the challenges of disaster recovery more effectively by ensuring a robust exchange of support and information across different social groups [1].

## 1.3. Interorganizational Collaborations

Disaster management calls for a level of cooperation that transcends the capacity of individual organizations. This necessity has prompted a shift from rigid hierarchical structures to adaptive, network-oriented collaborations. These networks, which incorporate entities from government, non-profits, and the private sector, form the backbone of disaster response and recovery operations [2].

Understanding the structural complexities and the dynamics of these networks is essential. They are layered, with each stratum playing distinct roles across the disaster management spectrum, from prevention and mitigation to active response and recovery. For instance, the rapid and reactive nature of response networks contrasts with the long-term, strategic alliances aimed at mitigation.

The strength of these networks lies in trust and the accumulation of social capital. Both formal and informal relationships are pivotal in mobilizing resources and coordinating activities swiftly. Yet, establishing and maintaining such networks is full of challenges. Conflicts in organizational culture, unclear roles, and capacity disparities can significantly inhibit collaboration.

In practice, the abstract concept of networked disaster response is brought to life through well-defined structures, as exemplified by Figure 2. This figure graphically depicts how primary and secondary organizations within Orange County, Florida, are organized around specific emergency support functions, with each entity playing a targeted role in the broader response effort. Circles represent the organizations actively engaged, while the squares denote the diverse support functions they fulfill, capturing the essence of collaborative response in a networked environment [2].

As networks evolve amidst the chaos of disaster response, they must assimilate new information and experiences. Social network analysis is a powerful tool in this regard, illuminating the patterns of interaction and flow of information that define these networks. It identifies key nodes and links, determining the network's capacity to achieve its goals. The Interorganizational Network Meta-Matrix (Figure 1) presented by [2], details the connections across various domains such as communication, knowledge, resources, tasks, and functions. This matrix is instrumental in understanding how these domains interact and influence each other, shaping the collective response to disaster scenarios.

## 2. Understanding and Analyzing Social Networks in Disasters

Disasters often scatter and create spontaneous social connections, leading to the formation of new, dynamic networks. Understanding these networks on various levels—from individual to community—provides valuable insights into how societies cope and recover from catastrophes.

### 2.1. Network Approaches to Understanding Disasters

In disaster scenarios, networks are critical for coordinating response and recovery efforts. The In/Out/Seekers/Providers (IOSP) framework, illustrated in Figure 3, helps identify the various roles and interactions within these networks, such as survivors seeking aid or external organizations providing support [3].

- **In/Seekers**: These are individuals or groups within the disaster zone who actively seek help, information, or resources from others within or outside the affected area. This group primarily includes local survivors and affected households that require immediate assistance.
- **Out/Seekers**: This group consists of external entities that are outside the disaster zone but seek to contribute resources or obtain information. They can include distant family members, international aid organizations, or researchers gathering data.
- **In/Providers**: Members in this category are within the disaster area and provide support, services, or resources to others in the affected community. Local government bodies, community organizations, and local NGOs typically fall into this category.
- **Out/Providers**: These are the external supporters who provide essential aid and resources from outside the disaster area. National governments, international NGOs, and other external donors are typical out/providers.

For example, in the wake of a natural disaster like a hurricane, the IOSP framework can help illustrate how local emergency services (In/Providers) collaborate with international aid organizations

(Out/Providers) to deliver relief. Similarly, it can show the pathways through which local residents (In/Seekers) receive information from local governments or through social media channels operated by distant entities (Out/Seekers).

## 2.2. Multi-Level Network Dynamics in Disaster Response

In the complex landscape of disaster response, understanding the layered interactions within social networks—from personal to community levels—is crucial. These layers reveal the diversity and scope of responses that can be mobilized during a crisis, each contributing uniquely to recovery and resilience building [3].

**Personal Networks and Direct Support** [3]

At the most personal level, individuals leverage their direct connections for immediate support. These networks typically consist of family, friends, and neighbors who provide each other with crucial resources such as food, shelter, and emotional support during emergencies. For example, after a flood, it is often these personal ties that facilitate the rapid sharing of information about safe zones or available resources. The strength and reach of an individual's personal network often play a significant role in their initial survival and comfort immediately following a disaster.

**Organizational Networks and Structured Response** [3]

Moving beyond individual efforts, organizations, including NGOs and local government agencies, form structured networks that are pivotal in large-scale disaster operations. These groups develop unique interaction patterns that are often predefined by their operational protocols and humanitarian mandates. Their networks are characterized by a coordinated approach to aid distribution, logistics, and recovery operations. For instance, an NGO might partner with local businesses to distribute food supplies or with international agencies to secure medical aid. The effectiveness of these organizational networks significantly impacts the speed and breadth of disaster response and recovery efforts.

**Community Networks and Collective Resilience** [3]

At the broadest level, whole communities engage as collective units in response to disasters. This community network layer encompasses all local actors—both individuals and organizations—and represents the sum of all social interactions and support mechanisms within the community. Community networks are crucial for long-term recovery and resilience building as they embody the collective capacity to adapt and rebuild. The analysis of community networks helps identify key community leaders and resource nodes that are critical in mobilizing collective action and fostering community spirit in the aftermath of a disaster.

## 2.3. Capturing and Measuring Network Ties in Disaster Management

In the context of disaster management, effectively capturing and measuring network ties is essential for understanding how information, resources, and support are distributed within affected communities. Ties within a network are the connections between nodes (which can be individuals, groups, or organizations) and are crucial for the network's functionality, particularly in the dynamic and often chaotic environment of a disaster [3].

Network ties can vary significantly in their nature and purpose, especially under the stress of a disaster scenario:

- Communication ties are perhaps the most critical during an emergency. These ties represent the pathways through which information is shared, whether through direct communication like phone calls and texts or through broader broadcasts via social media and other platforms.
- Resource-sharing ties involve the exchange of material aid, such as food, water, medical supplies, and shelter. These ties are vital for the immediate survival of affected populations and require robust logistics and coordination to ensure resources reach those in need efficiently.
- Support ties encompass emotional and psychological support, which are indispensable during the high-stress periods following a disaster. These ties might connect family members, friends, or even link strangers who find themselves sharing similar experiences and challenges.

Accurately measuring these ties involves various methodologies:

- Surveys and interviews are commonly used to gather data directly from network participants. Questions might focus on the frequency of interaction, types of resources exchanged, and the perceived strength of the ties.
- Social media analysis has become increasingly important, especially for understanding communication ties. By analyzing data from platforms like Twitter and Facebook, researchers can identify key communicators and the spread of information.
- Observational studies involve directly observing interactions within a community or organization during a disaster. This method can be particularly insightful for understanding non-verbal cues and the dynamics of support within emergency shelters or relief centers.

## 2.4. Gaining Insights Through Disaster Network Analysis

**Network diversity** [3]

Network diversity refers to the variety of nodes within the network and the range of connections or ties these nodes possess. In a disaster context, a diverse network can include various actors like local authorities, non-profit organizations, community groups, and external aid providers. High diversity within a network can enhance a community's ability to access a broad range of resources and information. For instance, diverse networks are more likely to connect with external resources that bring in novel ideas and solutions that are not available within the local community. This can be especially valuable in areas where local resources are devastated or insufficient.

**The Role of Centralization** [3]

Centralization in a network indicates the extent to which network interactions are concentrated around one or a few nodes. In disaster management, highly centralized networks can be both advantageous and problematic. On the one hand, centralization can streamline decision-making and speed up response times, as fewer nodes may control resource distribution and communication. On the other hand, over-reliance on central nodes can lead to bottlenecks or failures if those nodes become overwhelmed or incapacitated. Therefore, while central nodes often emerge naturally or are structurally embedded in formal response agencies, it is crucial to develop strategies that can distribute responsibilities across multiple nodes to enhance network resilience.

**Connectivity and Network Health** [3]

Connectivity within a network refers to how well nodes are linked to one another, directly or indirectly. In disaster scenarios, high connectivity can improve the efficiency of information dissemination and resource sharing. Network analysis tools can identify if there are sufficient pathways through which information and resources can flow to reach all parts of the network. Identifying isolated nodes or clusters within the network allows coordinators to make targeted interventions to ensure no individual or group is left without support.

**Predictive Insights from Network Structures** [3]

By analyzing the structures of disaster-related networks, we can predict potential challenges and strengths in disaster response efforts. For example:

- Networks with high multiplexity (multiple types of ties between nodes) are robust and can facilitate various forms of support, enhancing the overall resilience of the community.
- Networks that exhibit high levels of reciprocity (mutual exchanges) foster stronger and more durable relationships, which are crucial in sustaining long-term recovery efforts.
- The presence of bridging nodes that connect different parts of a network can help in mitigating the effects of centralization by distributing the network's functional load.

### 2.5. Tackling Dynamic Disaster Networks

Disaster networks are ever-changing, with pre-existing ties adapting and new ones emerging in response to crises, as seen in Figure 4. This dynamism poses methodological challenges but is key to capturing the true nature of social structures during disasters [3].

In the pre-disaster phase, networks are typically dense with strong ties. These are built on routine interactions, established trust, and mutual support—like neighbors helping each other with daily tasks. They represent a network at equilibrium, with each node (individual or organization) positioned within a web of regular, predictable connections.

As the disaster strikes, the initial dense network often fragments. Key nodes may be displaced, regular communication channels disrupted, and the rhythm of daily interactions broken. The network becomes sparser as individuals focus on immediate survival rather than on maintaining extensive social connections. In this phase, networks pivot towards adaptability, shedding some of their density for agility. New, often temporary, ties are formed based on urgent needs rather than long-standing relationships.

In the aftermath, the network begins to reorganize. This reconfiguration is driven by immediate needs, such as securing food, shelter, and medical assistance. New leaders and central nodes may emerge, particularly those who can mobilize resources or provide critical information. These actors become pivotal in connecting different parts of the network, which may have become isolated due to the disaster. As such, the post-disaster network has a more practical and utilitarian structure than the pre-disaster one.

Over time, as recovery progresses, the network begins to resemble its original structure, but with notable enhancements. Some of the ties formed out of necessity during the disaster persist and strengthen the network, making it more robust. These enduring connections contribute to the community's resilience, equipping it to withstand future adversities more effectively.

## 3. Literature Review

### 3.1. Facebook Pages - Louisiana Flood (2016)

In the article [4], the researchers conducted a social network analysis of Facebook interactions following the 2016 Louisiana floods. The study focused on user behavior and the structure of online communities during this period of crisis. The methodology included data mining from the City of Baton Rouge's Facebook page, analyzing posts, comments, reactions, and the networks formed around shared content.

The key findings of the research highlighted the central role of individual Facebook users in disseminating information, which peaked immediately after the flood. Over time, interactions decreased, but the structure of the networks remained, pointing to the formation of a lasting community of support. A significant outcome was the identification of key actors and organizations

within the network, denoted by their high level of centrality and betweenness, signifying their role as major information disseminators and connectors in the network.

In terms of visuals from the article [4], the following figures are particularly important for illustrating these findings:

- Figure 5 illustrates the types of relationships between Facebook users, clarifying how information spreads through shared posts, reactions, comments, and tags.
- Figure 6 shows the overall network graph during the disaster, highlighting the users and organizations with the highest out-degree centrality—those who shared information most frequently.
- Figure 7 shows the top 10 most important communities within the network.
- Figure 8 depicts the community structure within the network, revealing how different groups (G1 to G10) interacted and shared information regarding various aspects of the flood response.

## 3.2. Twitter Pages - Hurricane Harvey (2017)

The article [5] conducts a detailed examination of how various government and emergency management organizations utilized Twitter as a platform to communicate with the public during the different phases of Hurricane Harvey. This study is grounded in the Situational Crisis Communication Theory (SCCT) and employs semantic network analysis to understand the nuances in messaging.

Hurricane Harvey, a Category 4 storm, hit the Gulf Coast of Texas in August 2017, resulting in significant damage and disruption. During this crisis, government and emergency organizations actively used Twitter to disseminate information, manage the disaster, and communicate with the public.

The research analyzed official tweets from 67 government and emergency management organizations over three weeks encompassing the pre-, during, and post-disaster stages. Semantic network analysis was used to examine the frequency and patterns of concepts in tweets, which shed light on the organizations' use of SCCT-recommended crisis response strategies. The concepts were then clustered into themes reflecting the key focuses of tweets at each stage of the disaster.

1. **Pre-Disaster**: Tweets were focused on disaster preparation, with frequent mentions of weather services and preventive instructions. The strategy of instructing information was predominant, guiding the public with what actions to take.
2. **During Disaster**: The focus shifted to action mobilization, with organizations tweeting real-time updates, assistance needs, and safety instructions. Both instructing information and bolstering strategies were used, with a slight emergence of adjusting information strategy.
3. **Post-Disaster**: The bolstering strategy became more prominent, with messages aimed at boosting community morale, expressing solidarity, and coordinating recovery efforts. The communication goals evolved from informing to mobilizing for recovery, with federal agencies like FEMA becoming more central in discussions.

From the shared visuals, such as semantic network maps and thematic clusters, it appears that:

1. The **pre-disaster stage**, had a clear focus on preparation, with key actors like weather agencies being central in the network (Figure 9).
2. **During the disaster** stage, there was a greater interconnection between themes, reflecting a more complex and immediate response involving various actors (Figure 10).
3. The **post-disaster** stage showed a shift toward community rebuilding and recovery efforts, with messages fostering a sense of unity and collective identity (Figure 11).

## 3.3. Aila cyclone (2009)

The research article [6] provides an empirical analysis of how social networks evolve in the aftermath of a disaster and the role they play in community resilience and disaster management. The

study focuses on a community affected by the cyclone Aila in 2009. The disaster's impact prompted the exploration of how the community's social networks adapted during and after the event.

SNA was utilized to dissect complex networks within the disaster-hit community. Researchers conducted focus group discussions to conceptualize the disaster into four distinct phases—'extreme event,' 'immediate community response,' 'relief,' and 'rehabilitation,' plus pre- and post-disaster phases for comparative analysis.

Personal interviews with affected households collected network data across all phases, capturing the unique networks that formed with varying central nodes. In the study, the nodes represent individuals and households within the community, as well as external actors such as government agencies, NGOs, and political affiliates. The edges signify the relational ties—such as kinship, friendship, informational exchange, or aid provision—that connect these entities. During the disaster, existing social ties (edges) were activated, and new ones formed, with community members (nodes) engaging more closely to manage the crisis.

Some of the main findings of this article are:

- Network density and centrality metrics increased immediately post-disaster and then decreased through the relief and rehabilitation phases, before rising again in the post-disaster phase. Figure 12 compares the pre- and post-disaster networks, demonstrating the increased number of ties and mean centrality scores, while Figure 13 shows actors with higher betweenness centrality post-disaster.
- Early-phase networks were characterized by endogenous nodes and ties, whereas later stages displayed networks with a core central structure composed of both internal and external nodes.
- The study revealed that early disaster response was primarily managed by the community's intrinsic social network. As time progressed, these networks evolved, with key actors emerging to facilitate information flow and external support.
- A shift in central actors was noted in post-disaster phases, with new central actors, often external and politically affiliated, emerging and helping the community access public rehabilitation resources. The emergence of new central actors, particularly those external to the community such as political party members, in post-disaster phases can be visualized in Figure 13, Figure 14, and Figure 15.
- Post-disaster social networks showed increased density compared to pre-disaster networks, suggesting some emergency ties created during the disaster phases remained and became part of the community's social network. Figure 12 represents the network post-disaster with more ties and a higher degree of average connections compared to the pre-disaster phase

## 3.4. Sri Lanka Floods (2017)

The article [7] examines the crucial role of social support networks in flood disaster preparedness and recovery in rural Sri Lanka, particularly following the 2017 flooding event. Sri Lanka frequently experiences flooding, which often overwhelms the established infrastructure and resources. The floods affected the catchment areas of the Kalu and Kelani rivers, leading to widespread inundation and displacement of people. The strong social network backdrop of Sri Lanka, noted for its rich cultural heritage and robust community interactions, formed the basis of the study.

The researchers selected flood-inundated households across several rural areas for a questionnaire survey. Additionally, semi-structured interviews, focus group discussions, and field observations were conducted. The research aimed to understand the characteristics and changes over time in the social networks that aid in disaster preparedness and recovery, focusing on the exchange of information, food, water, evacuation, shelter, and other essentials.

The spatial and temporal patterns of the networks emerged as a key aspect of the study, showing that support networks' dynamics varied based on their geographic locations, with some remote areas facing greater challenges due to inaccessibility during floods. The nodes in these

networks represented individuals or groups such as Governmental Non-Officials (GNOs) and volunteers, with the edges representing relationships or exchanges among them. For example, key actors like GNOs played central roles in coordinating flood support, especially during and after the inundation events.

The findings revealed that the characteristics of social support networks altered significantly over time, with degrees of network centrality metrics such as closeness and betweenness increasing post-disaster and evolving during the relief and rehabilitation phases. The study found that initial disaster response was primarily handled within the community's inherent social structure. Over time, networks evolved to include key actors from both within and outside the community, facilitating access to external support and resources. The study underscored that post-disaster social networks were denser than pre-disaster ones, indicating that some emergency ties remained and became integrated into the community's network, as seen in Figure 16.

# 4. Conclusion

In conclusion, social network analysis offers an essential framework for enhancing the effectiveness of disaster management. The complex and ever-changing nature of social networks in disaster contexts demands an approach that is both analytically rigorous and adaptable to real-world complexities. As we continue to face the challenges presented by natural disasters, the strategic application of SNA stands as a flicker of hope, guiding efforts to not only reconstruct the physical world but also to fortify the human connections that sustain communities in the most difficult times.

The dynamic nature of disaster-induced networks reveals a strategic advantage. Adaptation and evolution within these networks can enhance resource distribution and recovery initiatives. Learning from the flow of these networks' transformations, we can better prepare for future disasters by cultivating a more adaptable and robust network infrastructure.

Balancing homophilous ties for immediate disaster response with bridging ties for sustainable recovery has emerged as a vital strategy. It's imperative to maintain a network structure that is not only rapid to mobilize but also capable of integrating a diversity of resources and perspectives, thus ensuring long-term community recovery.

This paper recommends that future research should continue to explore the use of SNA in understanding the nuances of disaster-related networks. Practitioners can leverage SNA to craft targeted interventions and foster network ties that contribute to a more resilient social fabric. Additionally, investing in training for key network nodes can amplify their impact, potentially leading to more effective disaster responses.

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# Appendix - Figures

| | *Agents* | *Knowledge* | *Resources* | *Tasks* | *Functions* |
|---|---|---|---|---|---|
| *Agents relation* | **Communication network** *Who knows whom* | **Knowledge network** *Who knows what* | **Capabilities network** *Who has what resource* | **Assignment network** *Who does what task* | **Affiliation network** *Who is responsible for what function* |
| *Knowledge relation* | | **Information network** *What informs what is shared* | **Skills network** *What knowledge is needed to use what resource* | **Needs network** *What \knowledge is needed to do what task* | **Competency network** *What knowledge is needed for which functions* |
| *Resources relation* | | | **Substitution network** *What resources can be substituted or shared for which* | **Resource dependence network** *What resources are needed to do what task* | **Community capital network** *What resources are needed for which functions* |
| *Tasks relation* | | | | **Precedence network** *Which task must be done before which* | **Sector responsibility network** *What tasks are assigned where* |
| *Functions relation* | | | | | **Interorganizational networks** *Who collaborates for what functions* |

*Adapted from Kapucu, N. (2006). Interagency communication networks during emergencies boundary spanners in multiagency coordination.* The American Review of Public Administration*, 36(2), 207–225.*

*Figure 1 - Interorganitional Network Meta-Matrix*

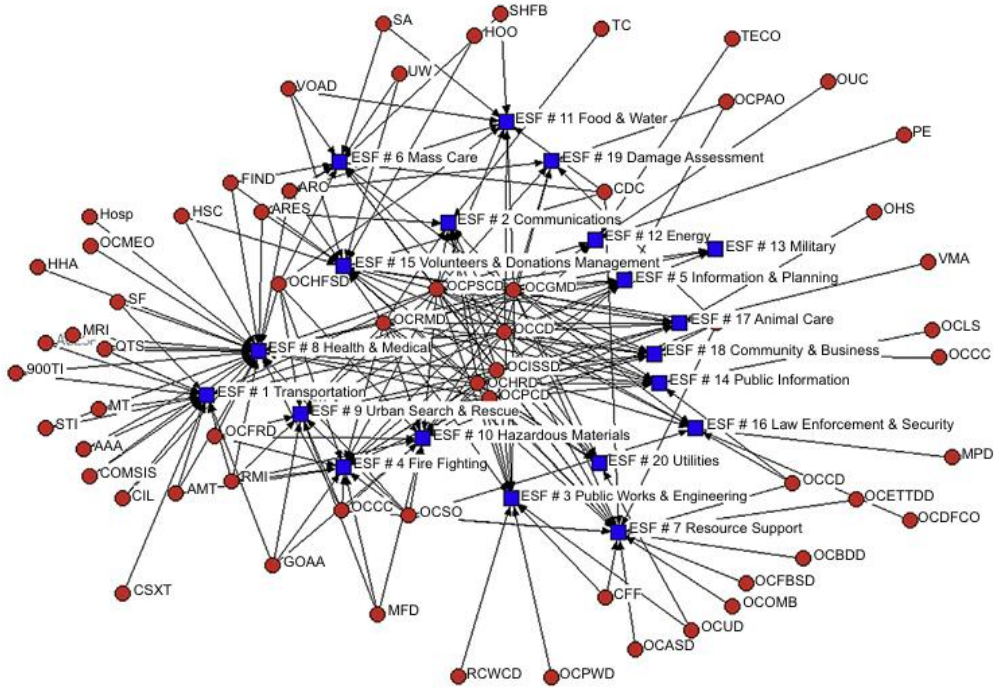



*Figure 2 - Orange County, Florida, emergency support function affiliation network*

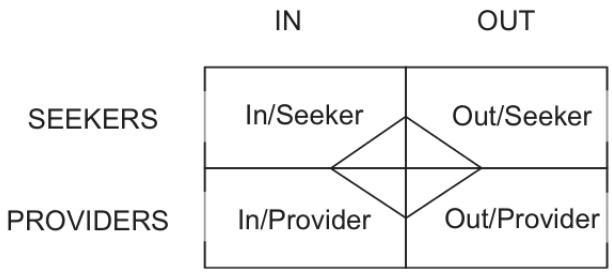



*Figure 3 - IOSP Framework*

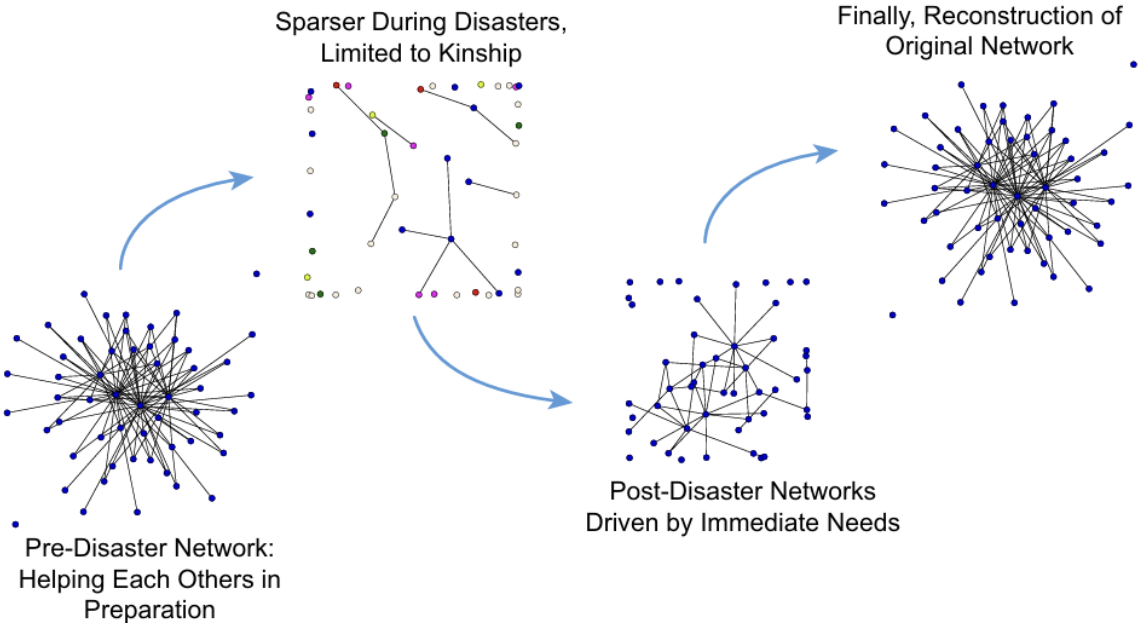



*Figure 4 - Evolution of a network pre, during, and post disasters*

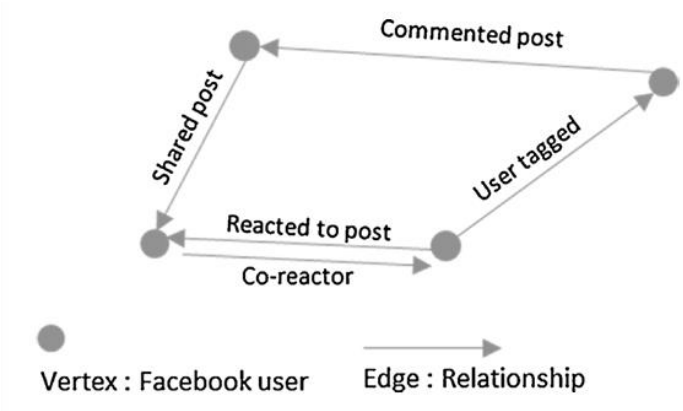



*Figure 5 - Louisiana Flood: Illustration of users and relationships*

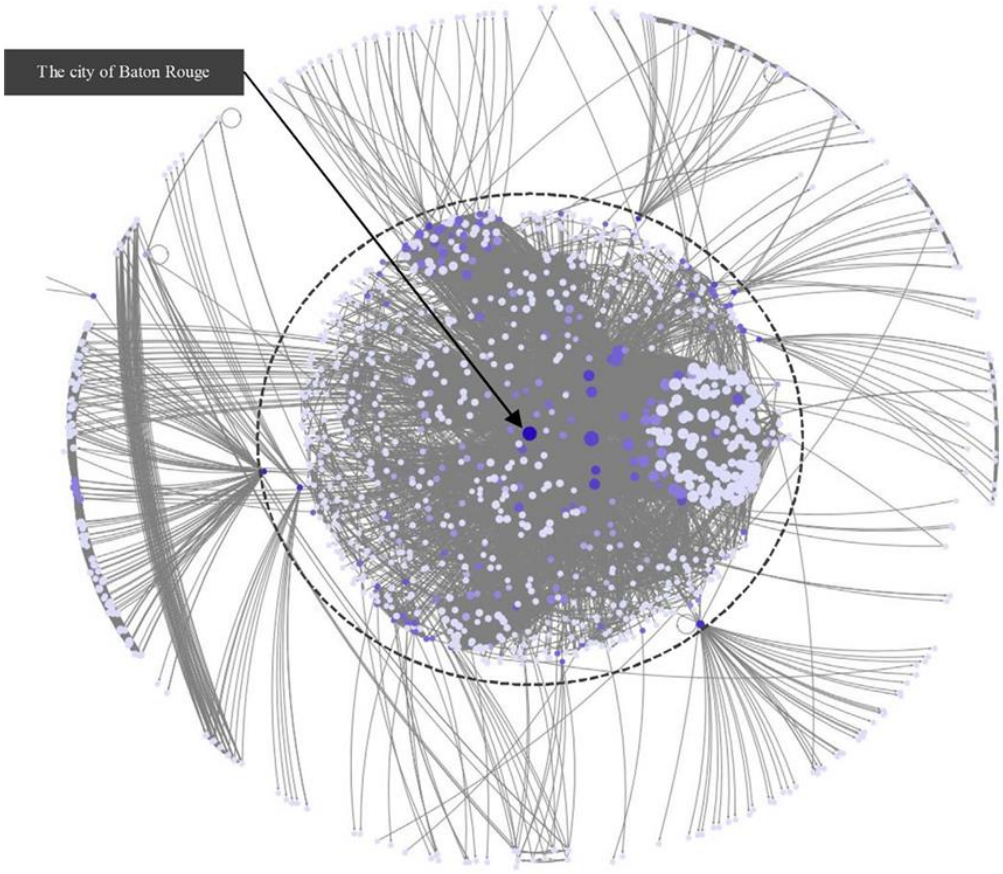
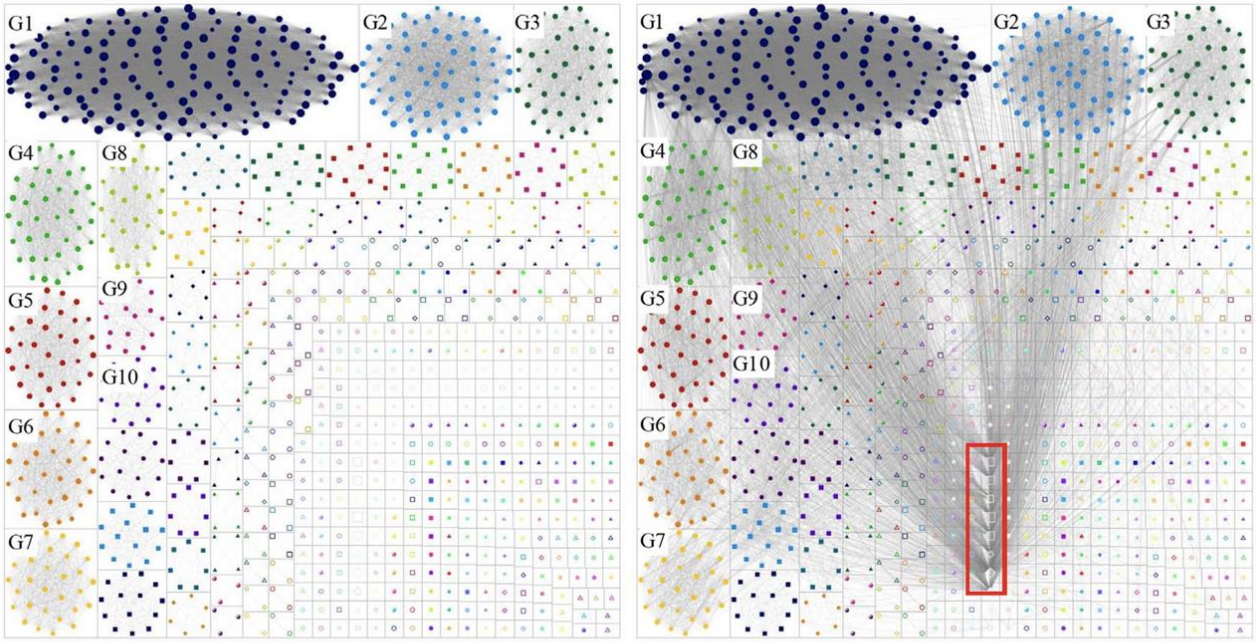



*Figure 6 - Louisiana Flood: Network Graph*

| Rank | Size | Description |
|---|---|---|
| G1 | 144 | Flood inundation map, information of debris separation, shelter locations |
| G2 | 63 | Commenters on the flood inundation map − e.g., map update requests and sharing map information |
| G3 | 43 | Donations and supports |
| G4 | 40 | Road conditions (road closed/open) |
| G5 | 34 | Locations of debris removal, debris collection status map |
| G6 | 33 | Ordinances to help Baton Rouge residents; housing, noise ordinance waivers, waiving permit fees for structures damaged, policy changes |
| G7 | 30 | Debris separation, Louisiana Department of Environmental Quality |
| G8 | 28 | Reactors to hiring workers to help with debris removal efforts |
| G9 | 16 | Commenters on the debris removal hiring event |
| G10 | 15 | City events after final debris collection |

*Figure 7 - Louisiana Flood: Top 10 largest communities*




*Community structure* *Interactions between communities*

*The primary divisions of community structure detected by the Girvan–Newman algorithm indicated by different vertex shapes and colors. Vertices in the red box played a role as a hub connecting G1 and G2.*

*Figure 8 - Louisiana Flood: Community structure*

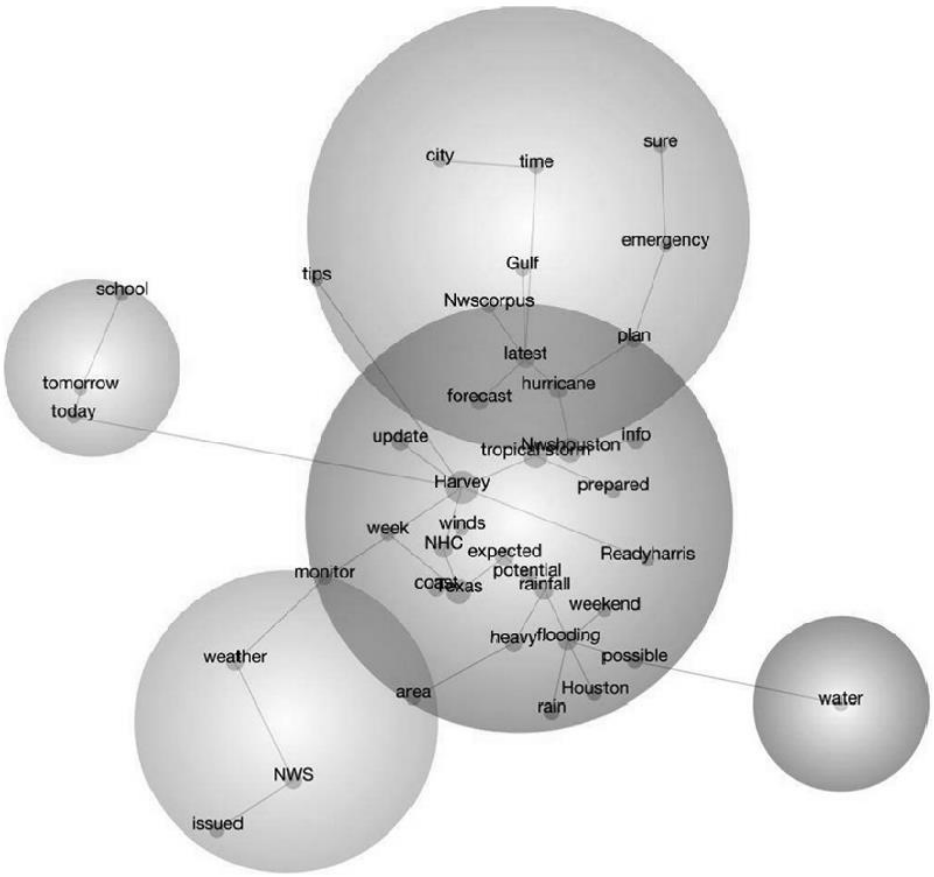



*Figure 9 - Hurricane Harvey: The semantic network of pre-hurricane tweets*

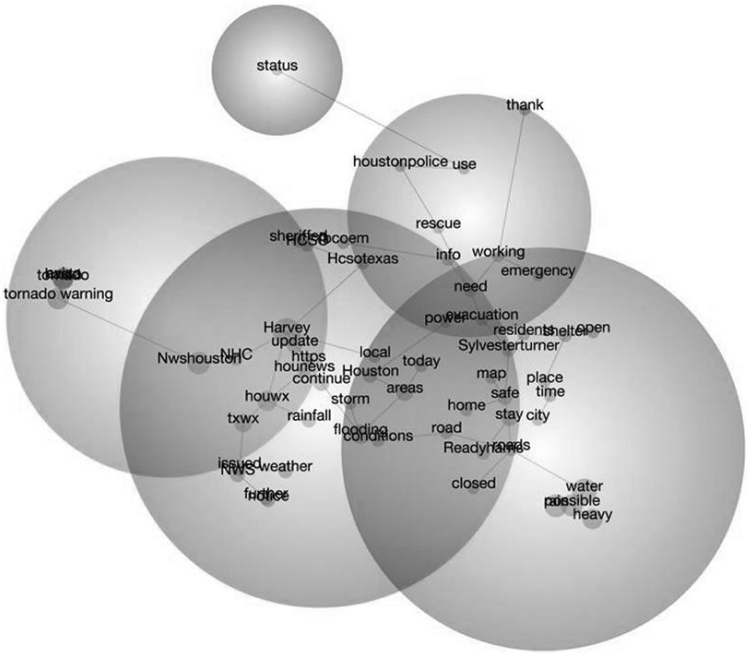



*Figure 10 - Hurricane Harvey : The semantic network of during-hurricane tweets*

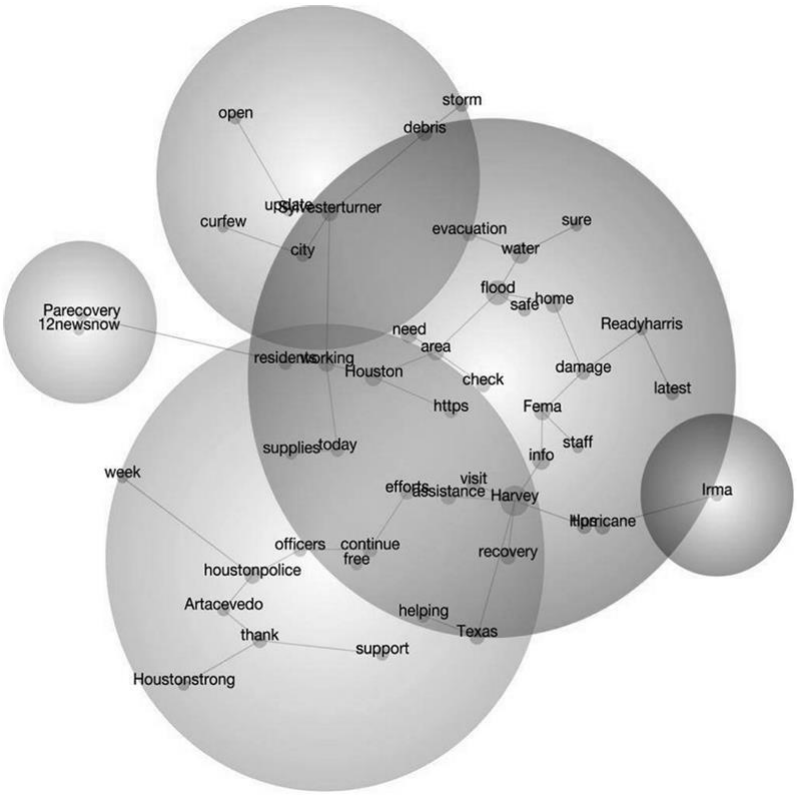



*Figure 11 - Hurricane Harvey : The semantic network of post-hurricane tweets*

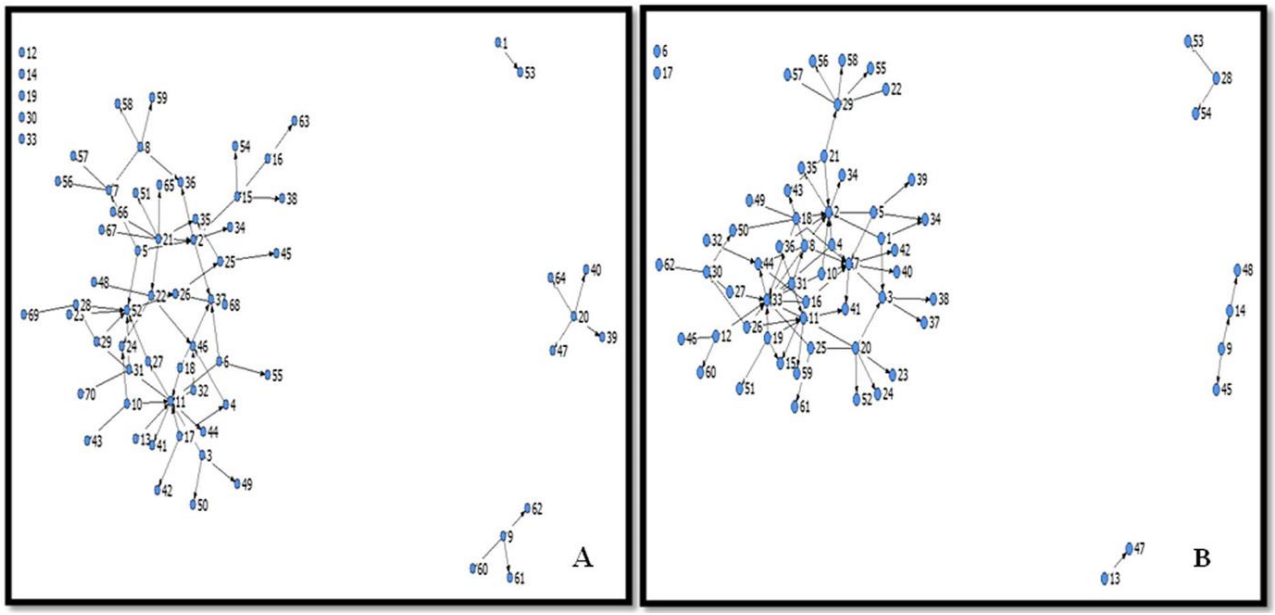



*Figure 12- Aila cyclone: Social networks before (A) and after (B) the disaster in the community*

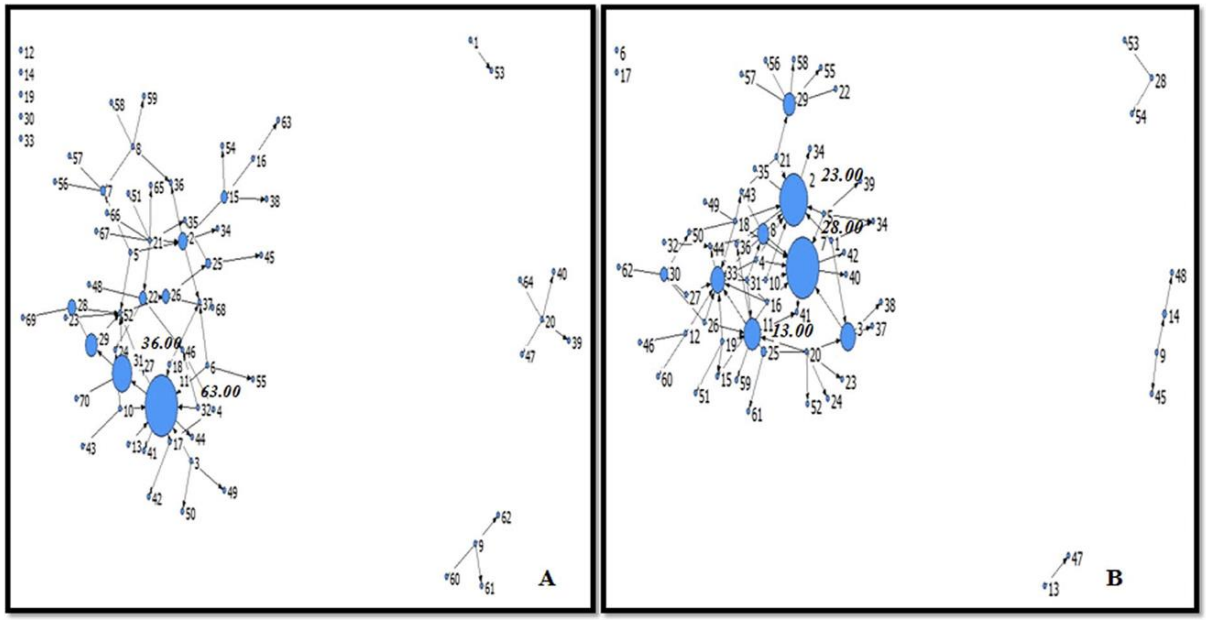



*Figure 13 - Aila cyclone : Social networks Betweenness Centrality before (A) and after (B) the disaster*

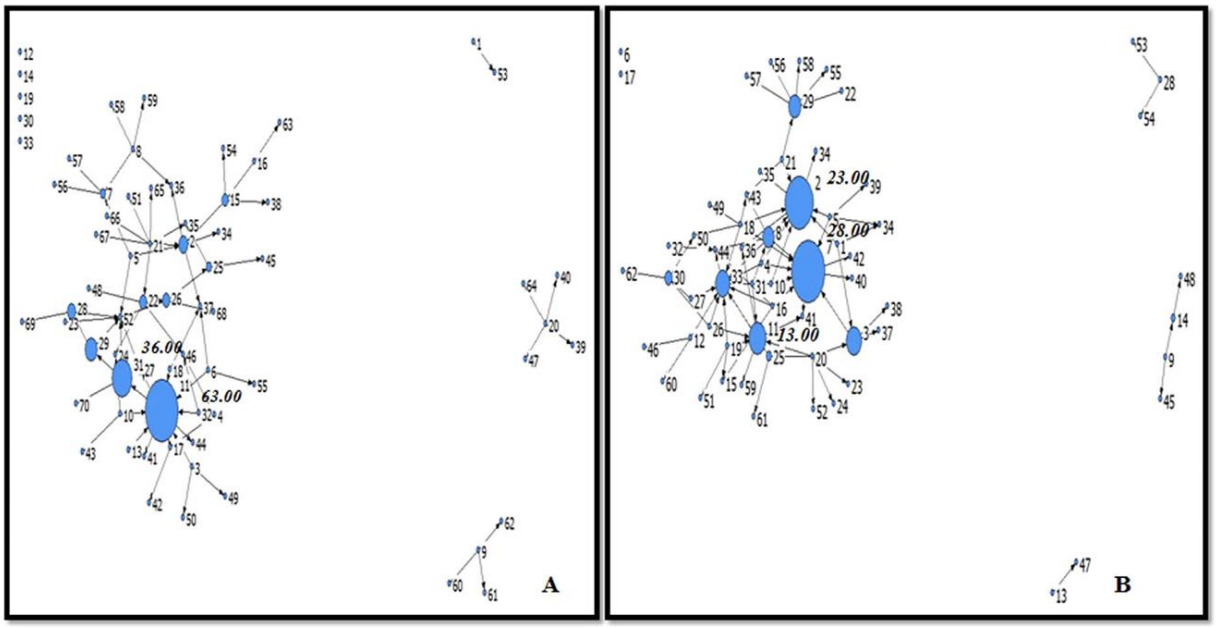



*Figure 14 - Aila cyclone: Social networks InDegree Centrality before (A) and after (B) the disaster*

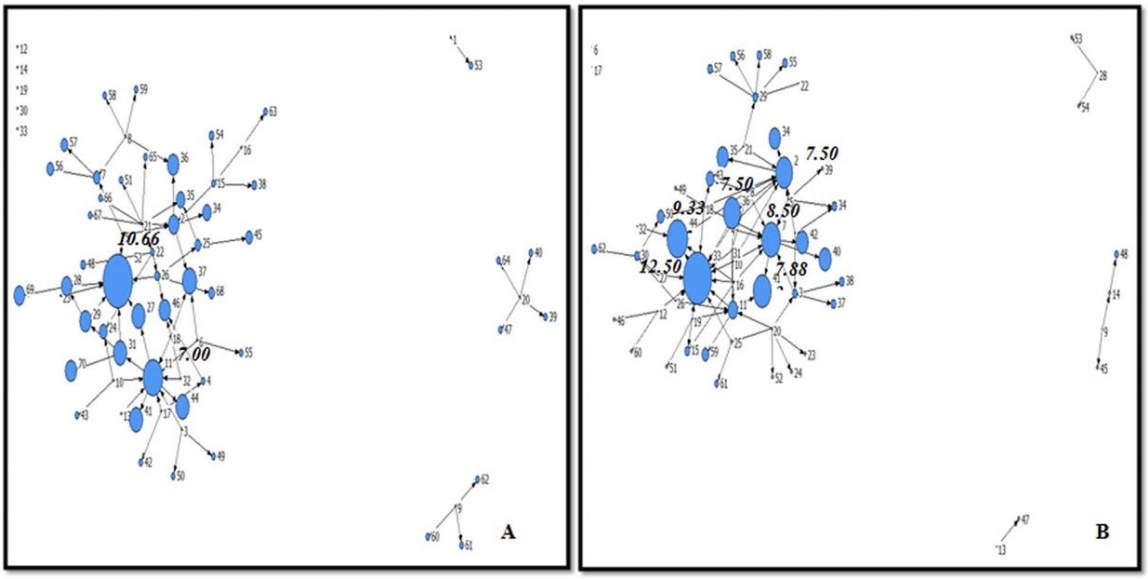



*Figure 15 - Aila cyclone: Social networks Closeness Centrality before (A) and after (B) the disaster*

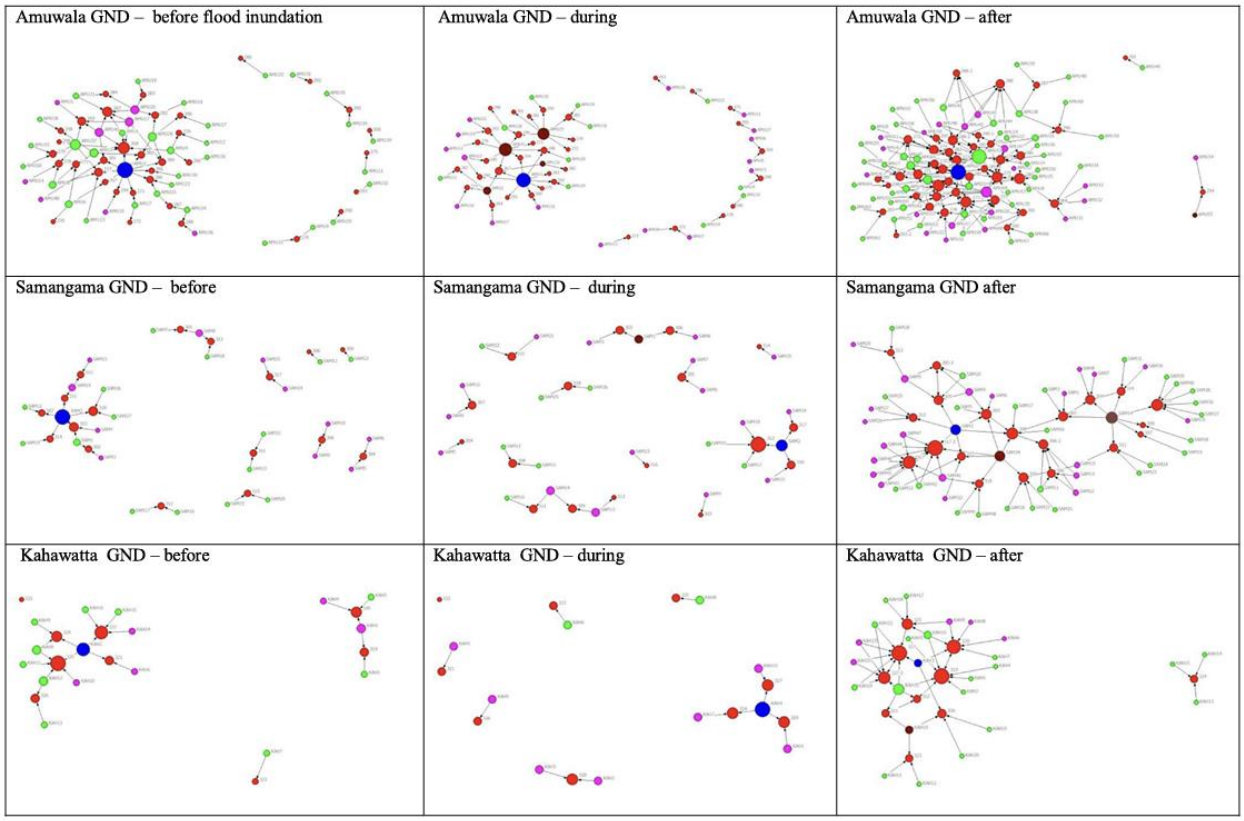



*Figure 16 - Sri Lanka Floods: Evolutionary patterns of social networks for flood inundation phases*