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ARTICLE

Evolution of Collaborative Governance in the 2015, 2016, and 2018 Myanmar Flood Disaster Responses: A Longitudinal Approach to a Network Analysis

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Abstract In disaster response, collaboration facilitates interactions among actors, such as the government, the military, nongovernmental organizations, and civil society organizations. This study examined the longitudinal changes in collaborative governance in Myanmar's disaster responses based on cases of flooding in 2015, 2016, and 2018. To examine the mechanisms underlying this dynamic network formation, the collaborative ties of the actors involved in search and rescue activities were converted into longitudinal relational data sets, and the evolution of collaborative governance was analyzed by relying on the assumptions of social capital, transaction cost, homophily, and resource dependency theories and using a longitudinal social network analysis method. The findings show that the collaborative networks of search and rescue processes in disaster response evolved and changed over time according to the hypothesized patterns of strong, weak, and preferential tie formations. The study also revealed that the collaborative governance system assumes the form of a hierarchy rather than a generalized exchange, and the actors' reliance on military organizations is not obvious due to the emerging alternative non-military actors and diverse local actors observed in the cases.

Keywords Collaborative governance · Longitudinal social network analysis · Myanmar flood disasters · Network sustainability

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1 Introduction

The Republic of the Union of Myanmar is a coastal country located on the eastern side of the Bay of Bengal and the Andaman Sea in Southeast Asia. Myanmar's tropical climate and location make it vulnerable to various types of hazards, such as forest fires, earthquakes, tsunamis, cyclones, floods, landslides, and droughts (Department of Meteorology and Hydrology, Myanmar 2009). Myanmar ranks 42nd on the World Risk Index, with a 9.06% chance of disaster, which is determined using a country's 5 year mean values (here between 2012 and 2016) of levels of disaster risk exposure, vulnerability, susceptibility, lack of adaptive capacities, and lack of coping capabilities (Kirch et al. 2017).

In recent decades, Myanmar has experienced many disasters, and by 2008, when Myanmar was exposed to devastating Cyclone Nargis, there was still no well-planned or well-organized institution that focused on disaster risk management. The military regime had failed to prepare and create a disaster management system, and Cyclone Nargis killed some 140,000 people and affected another 2.4 million people (Seekins 2009). In response, the government of Myanmar began paying attention to and prioritizing disaster risk management. The aftermath of Cyclone Nargis continued to impact the social and economic fabric of the affected communities for five years after the event.

After 2010, the regime transitioned from the military to the new civilian government in accordance with the new Constitution. The new government assumed responsibility in March 2011 and established the National Disaster Management Agency in April 2011, headed by the Union Minister for Social Welfare, Relief and Resettlement (Ministry of Social Welfare, Relief and Resettlement 2012). According to the new political structure and the

requirements of disaster management, the 23-member National Disaster Preparedness Central Committee, under the chairmanship of the Vice President, was reorganized from the National Disaster Management Agency in May 2013. Under the supervision of the Central Committee, 12 working committees and an advisory committee focused on specific themes of disaster management. Of these, the National Disaster Preparedness Management Working Committee was reorganized into the National Disaster Management Committee (NDMC) in March 2016. The government also enacted the Disaster Management Law in 2013 and the Disaster Management Rules in 2015 (The Republic of the Union of Myanmar 2015).

In July 2015, Myanmar experienced nationwide floods as a result of torrential rains from Cyclone Komen. The floods initially occurred at state and regional levels followed by landslides, especially in Chin State (Fig. 1).[1]Within a month, the floods spread to 12 states and regions simultaneously and became a large-scale disaster. The government declared Magway Region and Sagaing Region emergency regions and Chin and Rakhine States disaster-affected zones. Similarly, in July 2016, the torrential rains of the Myanmar monsoon season caused flood disasters and landslides in many states and regions. A year later, in the monsoon season of 2018, eight states and regions faced flash floods due to heavy rains, including irrigation dam overflow. These multiple flood disasters have repeatedly affected vulnerable groups of people throughout Myanmar at different degrees of magnitude at different times and have caused serious crises in communities and individual lives, which requires careful investigation beyond single independent disasters (Ray-Bennett 2009) of the coping capacities and sustainability of the individual relevant stakeholders and the stakeholders as a group who are involved in disaster management.

Under Myanmar's military regime, the military was the strongest and most well-organized institution in the country and was mainly responsible for disaster management. After 2010, consecutive civilian governments transformed the new administrative systems, including the disaster management system, but the military has continued to provide support for disaster management. Although the government of Myanmar has made significant progress with its disaster risk management (DRM) policies and plans, damages and losses have not significantly decreased. Government agencies sometimes have difficulty handling widespread disaster situations effectively. In such cases, the NDMC requires the police force, the fire brigades, the Red Cross, civil society, and nongovernmental organizations to provide assistance to disaster victims and, if necessary, requests assistance from the military to manage logistics and deliver services to victims (The Republic of the Union of Myanmar 2015).

The Constitution states that "The Defense Services shall render assistance when calamities that affect the Union and its citizens occur in the Union" (The Constitution of the Republic of the Union of Myanmar, Chapter VII) (The Republic of the Union of Myanmar 2008). The main disaster-response responsibilities of the Myanmar military are search and rescue, transportation and logistics, humanitarian assistance, relief and rehabilitation, and security. Myanmar has 161 search and rescue teams that are ready to deploy when disasters occur, including nine ships from the Myanmar Navy and transport aircraft and helicopters from the Myanmar Air Force (Hlaing 2016). As the country's disaster rescue agency, the military must support the government in responding quickly to catastrophic situations. The Myanmar Defense Services allocated funding for disaster response and assisted disaster victims by establishing relief camps and providing shelter, transportation, food, water, clothing, medicine, and essential services in 2015, 2016, and 2018 when large-scale flood disasters occurred in the country.

Myanmar uses a collaborative approach to disaster management. However, while the country's disaster management system is designed as a network system, the patterns and structures of the collaborative relationships among the actors involved have changed over time. The structures of network formation and collaborative governance are changing and evolving each year (Htein et al. 2018). This study examined the underlying mechanisms of longitudinal changes in collaborative governance in Myanmar for flood disaster response and aimed to answer three research questions: (1) What were the main forces that motivated stakeholders to collaborate with each other in a network? (2) How did the stakeholders choose their partners in a network? and (3) What were the longitudinal changes and dynamics of the collaborative ties in the disaster response work for search and rescue tasks in the 2015, 2016, and 2018 flood disaster events? To answer these research questions, the study employed a longitudinal social network analysis and tested various hypotheses derived from social capital theory, transaction cost theory, resource dependency theory, and homophily theory, all of which are associated with the formation of collaborative ties among stakeholders in a network. The findings of this study will help disaster management practitioners, policymakers, and scholars in developing or least-developed countries where the political environment around military forces is changing the understanding of the factors that

[1] There are no administrative differences between States and Regions. States are associated with other ethnic groups—such as Shan State (where the majority of the population is of Shan ethnicity) and Kachin State (where the majority of the population is of Kachin ethnicity)—and "Regions" are associated with people of Burmese ethnicity (Nixon et al. 2013).

Fig. 1 Overview map of Myanmar

support the sustainability of disaster response networks amid multiple disasters.

2 Organizational Collaborations in Disaster Settings

Multi-organizational collaborations have drawn increasing attention in disaster risk management (Hermansson 2016; Htein et al. 2018; Sapat et al. 2019). In the past, disaster risk management was mainly organized around traditional hierarchical structures and methods. However, this approach could not effectively handle multifaceted disasters and faced some intractable problems (Bier 2006; Klijn and Koppenjan 2007; Kapucu et al. 2013). Many aspects of disasters and emergencies are unforeseen and uncontrollable. As a result, scholars and disaster policymakers and practitioners are paying close attention to collaborative efforts in disaster management, which have proven to be feasible methods for tackling complexity and uncertainty in a timely manner (Kapucu et al. 2013; Chen et al. 2020).

Resolving complicated disaster issues through collaborative efforts is not a new approach, but the network form of implementation and the appearance of collaborative tools are now understood as a distinct phenomenon. It is not possible for a single individual or organization to manage all disaster relief and resettlement efforts. Disaster relief operations involve multiple highly complicated managerial factors, conditions, and needs regardless of organizational boundaries. Therefore, collaborative networks have become the foundation of disaster management (Waugh and Streib 2006). When a disaster strikes a country, multiple agencies, including central/local governments, fire service departments, disaster relief and resettlement departments, the military, medical services and police, and nongovernmental/nonprofit organizations collaborate through networks during and after a disaster (Robinson et al. 2013).

However, when a disaster is over, these collaborative network systems return to their normal status—a situation that results in a loose collaboration network. Weber (Weber 2003) suggested that a disaster management network should be sustainable and resilient before, during, and after the disaster to produce a more effective outcome. Sustainable networks depend on the organizational environment and organizational culture, in which not only several internal and external factors but also structural and relational factors are involved (Waugh and Streib 2006). Trotter et al. (2008) noted that network sustainability is crucially important for disaster management because collaborative networks over time can achieve more effective outcomes for disaster relief operations. However, organizations lack the capacity to maintain long-term relationships with other organizations, which means that those relationships may not be intact every time a disaster occurs. Some local organizations tend to dissolve or terminate ties with other organizations after their disaster relief operations are complete. After engaging in complex collaborative processes that involve a considerable number of public and nongovernmental actors for disaster response, the actors within a network are also likely to shift blame to one another for any observed failures during the emergency response phases and discontinue their engagement in collaborative activities related to future multiple disasters (Hood 2011; Lim et al. 2016; Lai and Hsu 2019). Therefore, organizations seek to build stronger relationships and to sustain their networks by sharing information, knowledge, and resources for the community's overall benefit (Provan and Milward 2001).

The organizations involved in disaster relief management have different knowledge, skills, backgrounds, and interests in disaster management given that they are from different sectors, levels, and fields (Berchtold et al. 2020). Therefore, disaster relief management is a type of multi-

organizational formation. Effective disaster relief operations and management depend on the coordination of diverse stakeholders such as government organizations, military organizations, and nongovernmental organizations. The participation of nongovernmental organizations can sometimes be limited by their own organizational structures and by the standard operating procedures (SOPs) of government organizations, as observed in the 2008 Wenchuan Earthquake (Lu 2017). Each organization is required to understand its own responsibilities and the expected roles that are clearly defined by the lead organization to achieve better outcomes and effective collaborative networks in emergency response processes, such as disaster relief operations. Ineffective collaboration—for example, information asymmetries, delays in search and rescue in disaster-affected areas, and communication gaps—can cause negative effects for citizens and victims (Htein et al. 2018). Therefore, sustainable and resilient collaborative networks are primarily important because they perform the complex tasks of disaster recovery and engage in preparedness processes throughout the multiple stages of emergency situations.

Even in the cross-sector and multi-organizational collaborative settings of disaster management, military involvement in humanitarian assistance and disaster relief has been a critical part of disaster management networks (Sylves 2008). International and national military forces have played a pivotal role in providing aid and support during disasters due to their strength in logistical and organizational operations (Apte 2009; Barber 2011; Heaslip 2011; Heaslip et al. 2012). For example, in response to the 2015 Gorkha Earthquake and the following earthquake in Kathmandu, Nepal, which killed an estimated 9000 people and devastated most of the region's infrastructure, the Nepal Army played a vital role and demonstrated its excellent capabilities in contributing to national post-earthquake recovery and relief. The diverse assets of the Nepalese Army could be promptly mobilized and provided medical care and relief materials to the victims and disaster areas (Manandhar et al. 2017).

In Myanmar, according to Article 431 of the Constitution, the military must support and provide assistance to citizens and the Union in the event of a disaster, which means that military involvement in disaster response and management is mandated. Rietjens et al. Rietjens et al. (2007) argued that the main responsibility of the military in disaster relief is to ensure the security of the environment to support the various organizations involved in disaster response operations, communication, and transportation. Anderson (1969) stated that the organizational structure of the military can fulfill these requirements and that the military plays an important role during periods of disaster and war. The military has enormous assets, such as manpower, logistical supplies, and equipment, which are useful in disaster relief operations. Moreover, with its distinctive organizational and bureaucratic structure, the military can manage an immense amount of manpower and assets during large-scale disasters by distributing power along a hierarchy of authority in accordance with its rules and regulations.

The Myanmar military has already been deployed all over the country, and it is the only organization that can promptly respond to disasters because of its readiness in terms of its well-trained personnel, its well-organized systems of operation, and its chain of command-and-control. Disasters, as unpredictable catastrophes with seriously negative impacts on a society, lead military organizations to play a critical role in disaster relief operations. Using military assets solely for the purpose of security for the duration of an emergency is not an adequate approach given that emergency operations are very complex and dynamic, and other organizations require additional assistance from the military forces for search, rescue, and rehabilitation during and after a disaster (Ferris 2012; Heaslip and Barber 2014).

In Myanmar, the main tasks operated by the military in disaster management are intended not only to create a secure environment for other relief organizations and emergency responders to function properly in evacuation, search, and rescue activities but also to establish the basic conditions required to facilitate the recovery of disaster-affected areas to normality by providing humanitarian assistance (Zaw and Lim 2017; Htein et al. 2018). Most of the military's critical functions and skills that are mobilized and utilized across all stages of disaster response actually fall outside the original mission of the military, whose main responsibilities are to prevent war and secure nationwide peace (Sylves 2008). In particular, the recent change in the political environment in Myanmar with the regime transition from military rule to civilian control could restrict or affect the roles of Myanmar military forces compared to those of civilian authorities and nongovernmental actors.

3 Hypotheses

The network systems that operate for the purpose of disaster relief are not fully controlled and led exclusively by the government. They are also self-regulated as civil society organizations, and local and international nonprofit and nongovernmental organizations are also involved. From the social capital point of view, actors in a network try to foster a reputation of trustworthiness and credible commitment (Coleman 1994). Those who receive support from providers, for example, acknowledge those providers

by reciprocating with resources, information, and services when those providers need help at a later time (Willer 2009; Nakazato and Lim 2016). This means that organizations that receive support from the community tend to actively respond, in a cooperative manner, to other community organizations' requests for support. This generation and circulation of support could be extended to triadic relations such as the tendency of a friend of a friend to become a friend. The first way to sustain trustworthiness and credibility in a network system is to create two types of closely connected network structures: (1) reciprocal relationships and (2) transitive relationships (Nakazato and Lim 2016; Lim and Nakazato 2019). In these types of structures, organizations are densely linked with others and do not easily betray their partners in the support-sharing process. Organizations can reduce the cost of enforcing and monitoring the responsibility of their partners through previously established strong and bonding ties. These types of network dynamics are based on the sociological concept of embeddedness, which suggests that cohesive networks generate cooperation through informal contracts, and previous cooperation fosters trust and reputation. Densely connected ties help actors in a network collect information about and cross-check their partners' reliability. They promote informal communications beyond the regulations of formal contracts (Uzzi 1996, 1997)and the sense of membership or belonging to such a specific subgroup because strong ties can be a source of trust and reputation (Granovetter 1973).

The formation of reciprocal bonding ties between organizations can reduce problems with credibility in the network system by mutual deterrence in the support provision process (Axelrod 1984; Larson 1992; Williamson 1996; Nakazato and Lim 2017). These dyadic ties are characterized by the exchange of mutual support. This relationship can cultivate trustworthiness between organizations, which is important in facilitating collaborative processes because organizations directly support each other. Therefore, "reciprocal dyads" are used to measure this type of mutual collaborative relationship in the network (Fig. 2-1).

Hypothesis 1 (Reciprocal Dyads): In a disaster response network, when organization *a* initiates a request for support to organization *b,* organization *b* tends to request collaborative support from organization *a* in the future.

Triadic ties are denser than dyadic ties and become a more closed network in which we can more easily observe the behavior of organizations, share their reputations, and develop the function of network sanctions against the opportunism of free riders within the network (Coleman 1988; Larson 1992; Putnam 1995; Uzzi 1996, 1997; Nakazato and Lim 2016). The nature of organizations is that they tend to form relationships with their partner's partner to exchange resources and information. This type of transitive triplet (Fig. 2-2) can be translated into trustworthiness and credible commitments among organizations in networks, leading to the formation of support network clusters and tightly connected networks (Nakazato and Lim 2017).

Hypothesis 2 (Transitivity): In a disaster response network, when organization *a* initiates a request for collaboration to organization *b*, which initiates a collaborative request to organization *c*, organization *a* is likely to request collaboration with organization *c* the next time help is needed.

The organizations participating in a disaster management network are likely to seek reliable and credible partners for collaboration in the network system (Berardo and Scholz 2010). When network members have inadequate information and there is a potential threat of opportunistic behaviors from support providers, they seek support from popular partners that have already been repeatedly chosen by other members (DiMaggio and Powell 1983). Hence, some actors with a stronger reputation for resources and information become increasingly popular among the actors of the network system (Granovetter 1985; Burt 1992, 2005). To measure this type of tendency, "in-degree popularity" is used (Fig. 2-3).

Hypothesis 3 (In-degree Popularity): In a disaster response network, when organization *b* receives requests for collaboration from many actors, including *c*, *d*, *e*, and others, and its reputation spreads, organization *a* will also have a greater likelihood of requesting help from organization *b*.

Organizations might increase their shared indebtedness to each other in terms of giving and seeking help by engaging in the network. In this case, indebtedness refers to circulating and balancing favors among organizations. When organizations need to avoid indebtedness to each other, they tend to provide support and fulfill requests from organizations that have not received help from the network (Nakazato and Lim 2016). This type of generalized exchange could resolve the accumulation of indebtedness among the actors. They provide support to one another without expecting a return from the specific actors they supported. Rather, they wish to extend support and subsequently return to those actors to enhance the development of the transaction circle (Rao 2007). To observe this type of tie formation pattern, "cyclical triads" are employed (Fig. 2-4).

Hypothesis 4 (Cyclicality): In a disaster response network, when organization *a* requests help or support from organization *b*, which also requests help or support from organization *c*, organization *c* tends to subsequently request help or support from organization *a*.

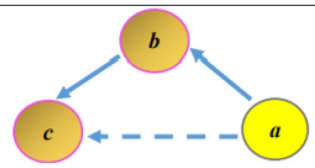
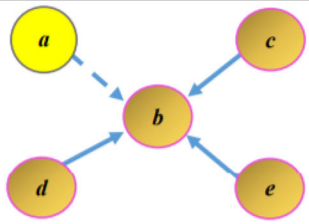
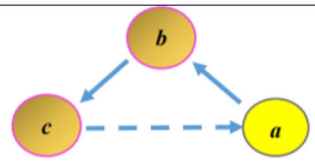
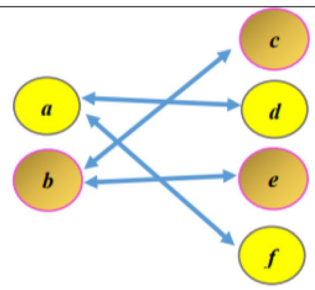
Network Structural Effects	Formation	Source of Linkages
1. Reciprocal dyads		Mutual deterrence; dyadic trust
2. Transitive triplet		Triadic group deterrence; triadic trust
3. In-degree popularity		Facilitation of efficient collaboration
4. Cyclicality		Generalized exchanges; avoidance of indebtedness within a network
5. Homophily		Mutual collaboration between members with the same organizational properties or characteristics

Fig. 2 Network formations for support *Notes: a* → *b*: *a* requests help or support from *b* at time *t; a* - - - → *b*: *a* requests help or support from *b* at time $t + 1$. *Source* Nakazato and Lim (2016)

Individuals or organizations have the tendency to establish a partnership with organizations with similar or the same cultural, economic, social, and organizational

properties or characteristics (McPherson and Smith-Lovin 1987; McPherson et al. 2001; Lim and Nakazato 2019). In the disaster management context, the involvement of multiple organizations with conflicting objectives and goals in the undertaking of similar operations could lead to resource wastage and poor coordination among them (Rietjens et al. 2007). Similar types of organizations involved in collective disaster response are likely to forge more partnerships or collaborative ties with each other to mitigate the potential opportunistic motivations or behaviors of other organizations through information asymmetry, and facilitate interactions based on their shared norms, missions, and goals (Celik and Corbacioglu 2010; Sapat et al. 2019). This type of networking—for example, partner selection based on the same type of organization (military to military, government organization to government organization, and nongovernmental organization to nongovernmental organization)—can reduce the cost inherent in partner-search processes (Fig. 2-5).

Hypothesis 5 (Between Civil Society Organizations): Civil society organizations are more likely to establish partnerships with each other in a disaster response network.

Hypothesis 6 (Between Military Organizations): Military organizations are more likely to establish partnerships with each other in a disaster response network.

Hypothesis 7 (Between Government Organizations): Government organizations are more likely to establish partnerships with each other in a disaster response network.

Hypothesis 8 (Between Nongovernmental Organizations): Nongovernmental organizations are more likely to establish partnerships with each other in a disaster response network.

When organizations in a network system have inadequate information relating to the reputation, availability, and reliability of partners, they are likely to approach resourceful members to resolve shortages of information and resources for collaboration (Pfeffer and Salancik 1978; Pfeffer 1997). In the context of disaster management in Myanmar, military organizations tend to be accessed frequently by other types of organizations in the networks because of the resources they possess within resource-scarce environments (Sylves 2008; Heaslip and Barber 2014).

Hypothesis 9 (Resource Dependency): Organizations are more likely to collaborate with military organizations in a disaster response network.

4 Case, Data, and Methods

This research methodology section outlines the selected cases, data, and adopted methods in this study.

4.1 Case Selection: The Floods of 2015, 2016, and 2018 in Myanmar

Every year Myanmar is exposed to heavy monsoon rains. In 2015, Myanmar's monsoon season began on 16 July with torrential rains. These torrential rains were exacerbated when tropical Cyclone Komen made landfall on 30 July. Flooding spread over 12 states and regions, especially Magway Region, Sagaing Region, Chin State, and Rakhine State. Torrential monsoonal rains caused both flooding and landslides in Chin State. The Union Government declared a state of emergency in the Sagaing and Magway Regions; the states of Chin and Rakhine were declared disaster-affected zones. Flooding and landslides devastated public transportation and communication, infrastructures, 89% of paddy fields, and 250,000 livestock. According to the National Natural Disaster Management Committee (NNDMC), 1.6 million people were affected, 211,709 households were displaced, and 122 people died from the disaster.

The monsoon season of 2016 began in early June with torrential rains that led to inundation in the northern part of the country. As a result of the heavy rains, Kachin State, Mon State, Yangon Region, Bago Region, Ayeyarwaddy Region, Magway Region, Mandalay Region, and Sagaing Region suffered from flood disasters. After heavy rains, the water levels increased in major rivers, especially the Ayeyarwaddy, Chindwin, Sittaung, and Bago Rivers; most of the residents who lived along these rivers became victims of the floods, and the rivers reached their highest recorded levels. According to the Department of Relief and Resettlement (2017), 521,293 people were affected, 129,399 households were displaced, and 11 people were killed by floods in 12 regions/states.

In 2018, residents from 12 out of the 14 regions and states faced flood disasters because the monsoon season again triggered heavy rains and the Swar Chaung Dam on Swar Creek in the Bago Region overflowed. Although the water levels of the rivers were expected to fall, they exceeded the flood stage in a short period of time. According to the Ministry of Social Welfare, Relief and Resettlement (2019), 360,703 people were affected, 45,927 households were displaced, and 34 fatalities were reported. That year, the Bago Region was the hardest-hit area among the 12 affected regions and states because the Swar Chaung Dam is located in that region. By comparison, the damage and impact of the 2016 and 2018 floods were less than those of the 2015 floods. Each year, government organizations, military organizations, nongovernmental organizations, and civil society organizations collaborated to respond and provide relief to the victims of these flood disasters.

4.2 Data and Method

In this study, multilevel stakeholders at the national, state, and local levels participated in disaster response. The relevant participants for this study were identified from news articles published in 2015, 2016, and 2018 and the annual reports of the Ministry of Social Welfare, Relief and Resettlement, followed by a multistage snowball sampling method (Prell 2012; Robins 2015; Borgatti et al. 2018). The initial seed set of the network members was selected based on news media articles and reports on the respective flood disasters in 2015, 2016, and 2018. Then, a subsequent set of organizations was also identified from the referrals of the seed set organizations of the network. Finally, after expanding the boundary of the network with this respondent-driven sampling method, the number of network members increased to 35 organizations. The engagement of governmental, military, nongovernmental (domestic or international) organizations, as well as civil society organizations, can be observed in these disaster management networks over time. As the participants across the 2015, 2016, and 2018 events are slightly different due to the different magnitudes, durations, and geographical locations of the cases, only the 35 common stakeholders that actually participated in disaster response activities for all three events were selected: 19 governmental, 3 military, 6 nongovernmental, and 7 civil society organizations.

These 35 actors were asked to complete a survey questionnaire focused on collaborative activities in disaster response developed by Zaw and Lim (2017), especially the

section on "searching for missing people and rescuing victims." This questionnaire was completed based on the actors' preference: face-to-face, telephone, or online. The data were collected from June to August 2016 for the 2015 flood (see Zaw and Lim 2017), from July to August 2017 for the 2016 flood (see Htein et al. 2018), and from July to August 2019 for the 2018 flood disaster. After identifying the participants, we collected a data set that consists mainly of basic information on individual actors and collaborative relationships—including not only formal mandated ties but also informal voluntary ties—among the actors in the search and rescue activities. These relational data were transformed into longitudinal data sets according to their ties—that is, we constructed actor-by-actor (35 × 35) matrices, also called binary adjacency matrices, in which the cells show (0) the absence of a relationship and (1) the presence of a relationship. These longitudinal network data sets showed the network actors sending ties to other actors as well as the actors receiving ties from senders within a set of actors.

In addition, we organized a data set based on the type of organization. We identified four groups—government organization, military, nongovernmental organization, and civil society organization—based on the attributive properties of the network actors to analyze the homophily effects on their formation of collaborative ties. To measure the collaborative efficacy indicating the participating actors' satisfaction with their collaboration with others, four general questions with five Likert scales—adapted from Thomson et al. (2007) and developed by Zaw and Lim (2017)—were also included in the survey questionnaires, and the summed scores of the four items were used in the analyses.

Methodologically, the Simulation Investigation for Empirical Network Analysis (SIENA) technique (Snijders et al. 2010; Ripley et al. 2013) was applied to analyze the longitudinal changes and dynamics of collaborative ties in disaster response networks based on the three Myanmar flood disaster cases. The SIENA approach is appropriate for modeling longitudinal changes in networks or network dynamics in terms of the individual actors' decisions to change their own tie formations (Lim and Nakazato 2020; Nakazato and Lim 2020). In this model, the network dynamics are determined by the individual actors' choices to maximize their utility by altering the status of collaborative ties with the other actors in a network—that is, creating new links, perpetuating current links, or abolishing former links (Nakazato and Lim 2016).

The sociograms for the collaborative ties mediated by search and rescue activities among organizations over the three flood disaster cases in Myanmar are shown in Fig. 3. The arrow connections in each sociogram depict the relationship between two organizations within the network—from the requester for collaboration to the organization receiving such requests and providing support to that requester.

5 Results

The research period of the Myanmar flood disaster responses was divided into the three subsequent flooding cases that occurred in 2015, 2016, and 2018 to examine substantial changes in the collaborative ties for the search and rescue activities. Table 1 shows the number of ties formed, continued, or terminated by stakeholders over two cases and some properties of whole networks for each case. The average number of collaborative ties by actors increased (1.17, 1.74, and 4.60), and the density in each case also increased (0.03, 0.05, and 0.13) over the three disaster cases, which motivates the longitudinal study of distinct network dynamics (that is, collaborative tie formations in this research).

To control for transitional changes in terms of geographical and temporal scales of disasters over three flooding events, the time horizons of the models are set differently: the overall periods across the three flooding cases in 2015, 2016, and 2018 (Models 1 and 2), the period between the 2015 and 2016 cases (Models 3 and 4), and the period between the 2016 and 2018 cases (Models 5 and 6), as shown in Table 2. To examine the hypothesized distinct structures of collaborative networking, two models with SIENA for each time horizon are specified into Models 1, 3, and 5 (for testing Hypotheses 1 through 8) and 2, 4, and 6 (for testing Hypothesis 9). Due to the observed consistency in the results for all the main hypothesized effects tested in this study across the models, we explain the findings based on the models for overall time periods (Table 2, Models 1 and 2) below.

The rate parameters, parameter 1 and parameter 2, are the estimated number of changes per actor between two subsequent flood cases. The estimated value of parameter 1 in Model 1 is 10.41 ($p < 0.05$), which means that changes in collaborative relationships among the actors occur more than 10 times between the 2015 floods and the 2016 floods. The estimated value of parameter 2 in Model 1 (17.26, $p < 0.01$) indicates that the actors are likely to change their collaborative ties with other actors more than 17 times between the 2016 and 2018 flood disasters. Furthermore, the estimated results of Model 1 show the significance of the network structural effects of reciprocal dyads (parameter 4, 0.89, $p < 0.01$) and transitive triads (parameter 5, 0.61, $p < 0.01$). These results indicate that there are strong signs of mutual and densely clustered support exchanges in the networks, supporting Hypotheses 1 and 2. That is, the organizations were inclined to build a relationship not only with their direct supporters but also with their supporters'

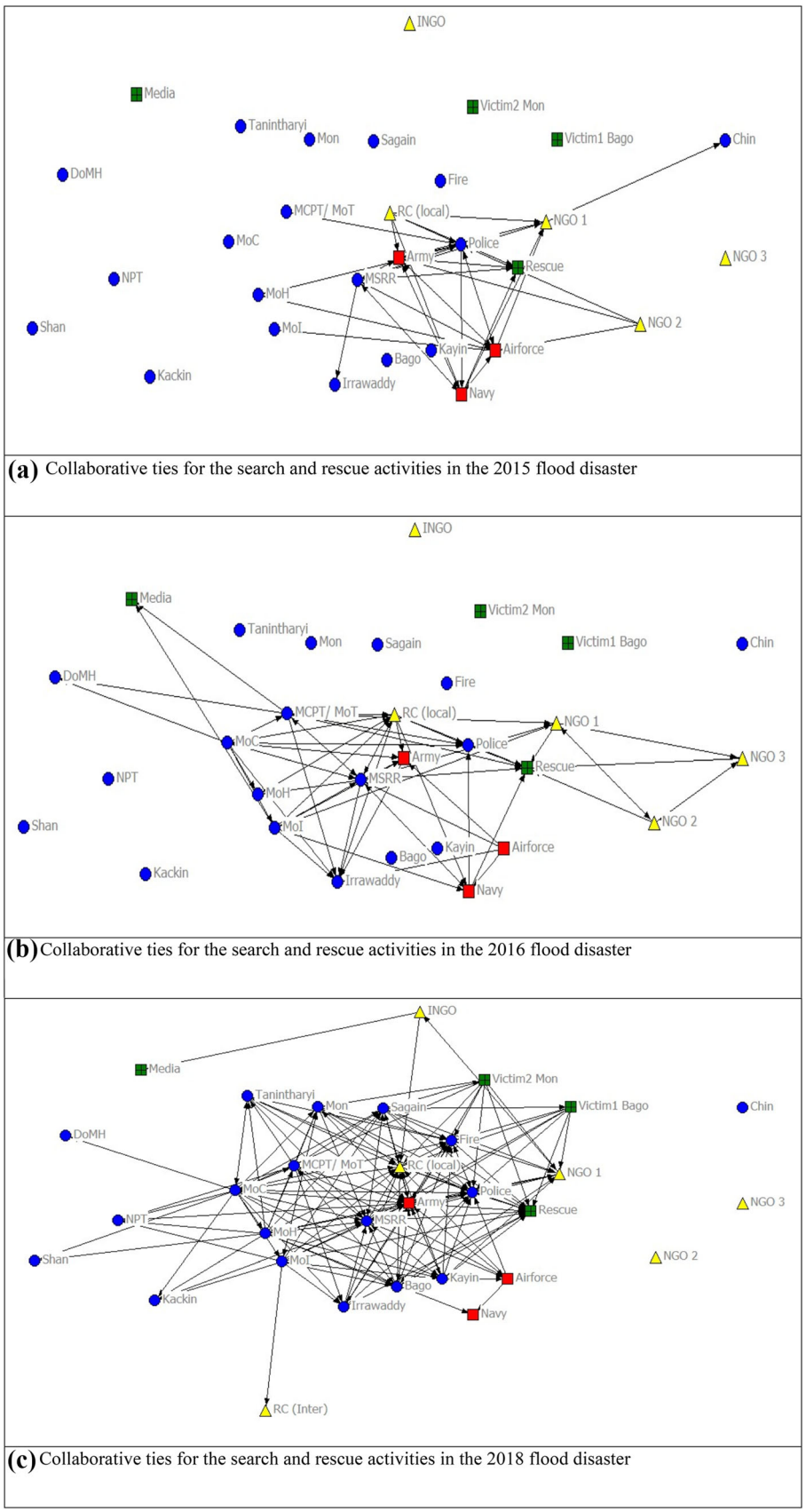


Fig. 3 Longitudinal changes in collaborative relationships for search and rescue activities over three flood disaster cases (2015, 2016, 2018) in Myanmar *Notes*: Organizations are indicated by arrowheads, and these arrows illustrate the directions of the collaborative relationships (that is, from the requesters for collaboration to the providers of support) among members in the disaster response network. The shapes and colors of the network members show their affiliation: government organizations (blue circles), military organizations (red squares), nongovernmental organizations (yellow triangles), and civil society organizations (green boxes). The organizations' abbreviations are as follows: Army (Army Command (local)), Navy (Navy Command (local)), Airforce (Air Force Command (local)), MSRR (local department of the Ministry of Social Welfare, Relief and Resettlement), MCPT/MoT (local department of the Ministry of Communication, Post and Telegraph / Ministry of Transportation), MoH (local department of the Ministry of Health), MoI (local department of the Ministry of Information), Police (local police department), MoC (local department of the Ministry of Construction), Sagain (Sagaing regional government), Irrawaddy (Ayeyarwaddy (Irrawaddy) regional government), Bago (Bago regional government), Chin (Chin State government), Rakhine (Rakhine State government), RC (local) (Myanmar Red Cross Society), RC (Inter) (International Red Cross Society), Rescue (rescue team), DoMH (Department of Meteorology and Hydrography), Fire (fire brigade), Kayin (Kayin State government), Mon (Mon State government), NPT (NayPyiTaw Union Territory), Kackin (Kachin (Kackin) State government), Shan (Shan State government), and Tanintharyi (Tanintharyi regional government)

Table 1 Changes in collaborative links for the search and rescue activities and whole network properties over multiple flood disasters in Myanmar

Changes in dyadic links	No link (0 → 0)	Newly forged collaborative link (0 → 1)	Discontinued collaborative link (1 → 0)	Sustained collaborative link (1 → 1)
From 2015 to 2016	1101	48	28	13
From 2016 to 2018	995	134	34	27
Changes in whole networks		2015 Flooding case	2016 Flooding case	2018 Flooding case
Density		0.03	0.05	0.13
Average degree		1.17	1.74	4.60
Number of total links		41	61	161
Number of mutual dyads		20	20	42
Number of asymmetric dyads		42	82	238

Table 2 Estimated results for network dynamics over the three Myanmar flooding cases H=Hypothesis; s.e.=standard error; sqrt=square root

Variables	Overall		From 2015 to 2016		From 2016 to 2018	
	Model 1 Estimate (s.e.)	Model 2 Estimate (s.e.)	Model 3 Estimate (s.e.)	Model 4 Estimate (s.e.)	Model 5 Estimate (s.e.)	Model 6 Estimate (s.e.)
Rate parameters						
1. From 2015 to 2016	10.41**	10.23**	14.67***	13.81***		
	(5.53)	(4.85)	(4.17)	(3.72)		
2. From 2016 to 2018	17.26***	19.04***			15.60***	17.10***
	(4.04)	(4.35)			(3.83)	(4.64)
Network structural effects						
3. Out-degree (density)	− 3.10***	− 2.82***	− 3.53***	− 3.67***	− 2.97***	− 2.65***
	(0.42)	(0.55)	(0.78)	(0.94)	(0.84)	(0.50)
4. Reciprocal Dyads (H1)	0.89***	0.92***	1.56***	1.67***	1.41**	1.50***
	(0.33)	(0.32)	(0.46)	(0.60)	(0.62)	(0.43)
5. Transitive Triplets (H2)	0.61***	0.56***	0.79***	0.91***	0.59**	0.53***
	(0.16)	(0.17)	(0.27)	(0.30)	(0.27)	(0.16)
6. In-degree Popularity (sqrt) (H3)	0.41***	0.40***	0.36*	0.45*	0.42***	0.40***
	(0.10)	(0.12)	(0.21)	(0.24)	(0.16)	(0.11)
7. 3-Cycles (H4)	− 0.62***	− 0.59**	− 0.88**	− 1.08*	− 0.51**	− 0.48***
	(0.19)	(0.24)	(0.39)	(0.60)	(0.23)	(0.16)
Attributive effects						
8. Same organization type (H5, H6, H7, and H8)	0.40***		0.45*		0.44*	
	(0.15)		(0.27)		(0.25)	
9. Similarity in collaboration efficacy	0.90	0.66	1.60	1.83	0.60	0.29
	(1.03)	(1.13)	(1.29)	(1.88)	(1.24)	(0.85)
Dyadic covariate effects						
10. Requesting support to military organizations (H9)		− 0.13		− 0.94		0.03
		(0.27)		(0.69)		(0.26)
11. Support requested from military organizations		0.05		− 0.21		0.12
		(0.28)		(0.57)		(0.29)

*Significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level. The coefficients are from the standard Simulation Investigation for Empirical Network Analysis (SIENA) longitudinal analysis of directional network matrices for 35 actors. All statistics converged with t statistics < 0.1 with a minimum of 1000 iterations.

supporters over time in these collaborative networks. These results also potentially demonstrate that the organizations in this disaster response network system sought to reduce any potential issues of credibility by embedding strong and close ties with their partners for mutual deterrence in the support provision process, with the goal of developing bilateral and triadic trustworthiness and commitment.

The negative coefficients of 3 cycles (parameter 7, − 0.62, $p < 0.01$) mean that the network members' support could not be reciprocated in an indirect way among the three members. In our proposition, we expected that the actors would likely resolve the accumulation of indebtedness in the collaboration network by providing support to the actors that previously provided support. However, this negative coefficient of 3 cycles rejected our expectation (Hypothesis 4) that the organizations in the network receive support as a form of generalized exchange and instead showed that the members in the collaborative network are unlikely to reduce their generalized indebtedness and to balance indebtedness among members. Furthermore, the significantly negative effect of cyclicality and the significantly positive effect of transitive triplets (parameter 5) indicated that the organizations tended to form local hierarchies in the collaborative networking process (Snijders et al. 2010). The significant coefficient of in-degree popularity in Model 1 (parameter 6, 0.41, $p < 0.01$), supporting Hypothesis 3, demonstrated that the members of the network system tended to request more reliable and credible partners for collaboration when they lacked information and faced the potential threat of opportunistic behaviors from support providers. Consequently, some stakeholders that were previously more reliable and credible in the disaster management networks became more popular among the organizations in this collaborative disaster response setting.

At the attributive level, the organizations in the same organization type (parameter 8, 0.40, $p < 0.01$) established a collaborative partnership in the network system, supporting Hypotheses 5, 6, 7, and 8. That is, organizations of the same type were more likely to enter into collaborative links. For example, military organizations were more likely to favor military organizations, and similarly, government organizations favored government organizations. These positive and significant sector-based homophilic interactions during the disaster response period are consistent with the results of previous studies conducted in different contexts of disaster response networks—such as after 2005 Hurricane Katrina (Siciliano and Wukich 2015), earthquakes in Indonesia, Haiti, and Japan (Siciliano and Wukich 2017), and the 2010 Haiti Earthquake (Sapat et al. 2019). Therefore, given the very short and urgent time frame during which new ties emerge amid disasters, through homophilic tie formation within the same sectoral boundary, organizations can hypothetically benefit from diminishing transactional costs, such as negotiation and bargaining costs of creating ties with each other.

In Model 2, at the dyadic level, we expected that military organizations would be more likely to be requested by other organizations because of their abundant resources (Hypothesis 9). However, the non-significance of "requesting support to military organizations" (parameter 10) demonstrates that the organizations in the disaster management network did not heavily rely on military forces. This result, based on the inferential network analysis of the longitudinal disaster response data set, reinforces the findings of a previous descriptive network study (Htein et al. 2018) of multiple-stakeholder disaster responses to Myanmar floods between 2015 and 2016 and implies that more governmental organizations assumed more critical positions in disaster response activities, including search and rescue, over time after the regime changed from military rule to a civilian democracy (Srikandini et al. 2018). Although military organizations were still actively engaged in search and rescue activities across the three disaster cases here, their role was embedded in state and regional government-led collaborative disaster management activities (Htein et al. 2018). Local military units in the disaster areas operated disaster response functions under the command and control of the regional army as well as the state and regional governments.

6 Conclusion

This research focused on longitudinal changes in the collaborative governance of Myanmar's flood disaster response in 2015, 2016, and 2018 by modeling the microdynamics of networks for search and rescue activities. The network structural systems were evaluated based on their formation and function from both economic and social perspectives. The social network approach employed in this study was able to observe the combination of both perspectives and unique structures of collaborative relationships, as the SIENA technique was employed to evaluate the formation of social capital and the minimization of transactional costs, which are fundamental to network development. Multiple hypotheses derived from social capital and transaction cost theories were tested to evaluate the longitudinal changes and dynamics in collaborative ties in the disaster response networks in Myanmar. The findings show that the collaborative networks for search and rescue tasks in disaster response evolved and changed over time according to the theoretically hypothesized structural patterns of tie formation.

The search and rescue activities of the network members in each flood disaster reveal the changes in their choices of

partners and the dynamics of the network. According to the results empirically supported in this study, the members in the network were embedded in densely connected cooperative relationships that could sustain collaboration among organizations over time. Close relationships and mutual trust are the factors that motivate organizations to cooperate within the network. Therefore, organizations have closely connected strong ties in the collaborative network. The organizations developed weak ties with popular collaborators in the disaster response network. Some organizations are more credible and reliable entities with which to cooperate and are more popular due to their sufficient resources. Therefore, members of the network requested to cooperate with these central organizations to reduce the transactional costs of negotiating, bargaining, and monitoring transactions. The findings also reveal the homophilic effects inherent in the emergence of collaborative networks. Thus, the organizations in the disaster response networks sought to reduce negotiation and bargaining costs and established partnerships with organizations of the same type. Interestingly, the result of the request to the military was not significant for the 2015−2018 flood disasters, although the military was the most resourceful actor in these networks due to its various assets, such as human resources, transportation, medical resources, and food. The military was still actively engaged in the disaster response network, but the requests for support went not only to the military but also to the other diverse types of non-military and locally emerging organizations in the three flooding cases. These results indicate the possibility that the embeddedness of stakeholders in a web of collaborative ties could sustain disaster management networks over time rather than the status or position of a specific actor with expertise and resources (for example, the military forces) in some developing or least-developed countries facing multiple disasters and political changes from military regime to civilian governance.

Although the current study empirically shows how a collaborative approach can be effectively used for search and rescue in vulnerable communities and to assist victims during and after disasters, there are also several limitations. This study focused on the search and rescue process during flood disasters by analyzing the network dynamics and partner selection mechanisms of network evolution across three different cases. Future research will be required to evaluate the collaborative changes that occur in other disaster response processes, such as information sharing, resource sharing, and humanitarian assistance, and their multiplex relationships over time. Furthermore, as this study adopted a relational approach and focused on interorganizational activities during disasters, less attention was given to support or aid provided independently by actors without other actors' requests. Future research conducted in interorganizational disaster management settings needs to not only emphasize interdependencies among stakeholders but also consider the potential omission of their independencies .

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