THE FORMATION OF INTERORGANIZATIONAL NETWORKS IN EXTREME EVENTS: A COMPARATIVE STUDY OF THE 1999 CHICHI EARTHQUAKE AND THE 2009 TYPHOON MORAKOT

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After catastrophic events, public, private and non-profit actors must find the means to act collectively to solve problems that do not stay within institutional and jurisdictional boundaries. Traditional hierarchical relationships do not provide governmental organizations with the means to solve such problems. Nor do traditional governmental structures enable organizations to work in collaborative networks. I propose a conceptual framework that argues that the formation of interorganizational networks is driven by formal structures and informal processes.

The purpose of this research is to explore the dynamics of collective action in a disaster response system. The conceptual framework used in this research is a synthesis of the literatures on network governance, complex adaptive system theory, institutional analysis and development, decision making, and policy change (Koppenjan and Klijn 2004; Kooiman 2003; Axelrod and Cohen 2000; Birkland 1997, 2006; Comfort 1999, 2007; Kettl 1993; Klein 1993; Ostrom 1999, 2005; Simon 1996, 1997). This conceptual framework was employed using a mixed-method case study design that investigated two disaster events that occurred in Taiwan: the ChiChi Earthquake in 1999 and Typhoon Morakot in 2009. Data were collected through a content analysis of newspaper articles

published in the *United Daily*, network analysis techniques, and semi-structured interviews with key informants that participated in the disaster response systems.

These data were used to address four research objectives. First, to identify the organizations involved in the disaster response systems. Second, to identify structure and evolution of the interactions exchanged among these organizations. Third, to identify the structure and process factors that encouraged organizations to interact within the response system. Finally, to identify the extent to which Taiwan's disaster response system learned after these two events. The findings indicate that the response operations that followed the ChiChi Earthquake and Typhoon Morakot were influenced by the tension between the need for administrative control and the need for adaptation and self-organization. The findings also indicate that disaster resilient response systems not only depend on shared cognition and the capacity to adapt during emergency situations, they also depend on striking the appropriate balance between structure and process.

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PREFACE

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1.0 INTRODUCTION

Human society is increasingly vulnerable to large-scale disasters (Mileti 1990). As the complexity of social structures increase, so too does the impacts caused by disasters, which now exceed the response capacity of traditional social systems. When catastrophic disaster events do occur, a diverse range of public, private and non-profit actors must find the means to collectively solve problems that exist outside of traditional institutional and jurisdictional boundaries.

Disaster events generate substantial social, economic and political costs. Due to the loss of life and property, disaster events can generate political pressures, which encourage the governments of affected societies to improve their capacity to response to disasters. Given that disasters are low probability events, and limited rational capacity, governments often seek to improve their disaster management systems by focusing on learning from previous experiences and maximizing the performance of formalized institutional structures.

Traditional hierarchical and chain-and-command power relationships, however, do not always provide governmental organizations with the means to solve the public problems caused by disasters. Nor do traditional relationships and structures provide governmental organizations with the means to work collaboratively, for example, with private and nonprofit organizations. However, history is rarely repeated. Formal structures are often vulnerable to disruptive events, as was observed during the South-Asia Tsunami in 2004, Hurricane Katrina in 2005, and the Great East Japan Earthquake in 2011. These events disrupted communications, transportation

infrastructures, lifeline systems and the command and control systems that formal structures relied on to operate.

The activities that occur after a disaster event are driven by dynamic and goal oriented processes in which organizations must constantly evaluate incoming information, recognize changes in the environment, initiate communication with organizations throughout the network, and coordinate with target organizations to acquire the resources needed to achieve their goals (Kooiman 2003). This decision making process can be influenced by several factors, for example, the institutional environment, information technology infrastructure, culture and norms applied to the organizations, and the management activities followed by individual organizations (Ostrom 2005; Comfort and Haase 2006; Poteyeva et al. 2007).

Although disasters are low probability events, the risks they present are widely shared by the entities that exist within a social system. To respond to these risks, governments must develop disaster management systems that have the capacity to adapt to changing environments and the capacity to form well-coordinated networks that include organizations from diverse institutional backgrounds. The development of such systems, however, requires that policy makers understand the network formation processes and the factors that influence the organizational decision making behaviors that promote and inhibit network formation.

This study, which investigates the formation of two disaster response networks in the Republic of China (Taiwan), attempts to address these issues. Taiwan was selected because it is one of the most vulnerable countries in the world. According to a report published by the World Bank (Dilley 2005), ninety-seven percent of Taiwan's territory is threatened by natural disasters, which include cyclones, floods, earthquakes and landslides. I identifies the initial conditions of the studied cases presented in the system, the response to the ChiChi Earthquake of 1999 and the

response to Typhoon Morakot of 2009, maps the development and evolution of the both event's response networks, and explores the factors that influence the process of network formation. With these two cases, this study is able to analyze the change of policies and how these changes influenced the formation of the network that responded to a disaster event that occurred ten years after the ChiChi Earthquake. This study not only contributes to the development of theory, it will help public managers to effectively allocate their energy and resources to coordinate collective action and leverage the efforts of networked organizational actors to achieve a common goal. Policy makers can also utilize this knowledge to examine and build the capacity of disaster management systems that must prepare for future disaster events.

1.1 THE NEED TO UNDERSTAND THE FORMATION OF INTERORGANIZATIONAL NETWORKS IN UNCERTAIN CONDITIONS

Governments, business and civil society increasingly face the challenge of solving social problems that are wrought with uncertainty (Koppenjan and Klijn 2004). There are various forms of uncertainty. Besides the uncertainty that comes from the changing environment and the lack of knowledge and information, decision makers also face the uncertainty caused by the dynamics of the actors in the system (Koppenjan and Klijn 2004: 6-7). It is difficult for governments to solve public problems without interacting with other actors in society. For example, decisions related to local economic development (Agranoff and McGuire 1998b), the provision of community-based health care services (Provan and Milward 1995), and the delivery of social services (Graddy and Bin 2006) are public management issues that involve interactions that must cross jurisdictions and the boundaries that separate the between public and non-public sectors.

Organizations exist in an interconnected system and cannot achieve their goals without taking other organizational actors into consideration. However, interaction dynamics increase the uncertainty that decision makers face when solving social problems (Koppenjan and Klijn 2004).

In the disaster response context, organizations from different sectors and jurisdiction levels, and operating with different rules, need to coordinate and adapt to constantly changing environments to achieve their goals. To solve complex problems, organizations can no longer operate according to a single standardized operational procedure. Organizations must recognize the dynamics present in the external system, process incoming information, identify the strategies that other actors may adopt, and take the appropriate action.

Organizations are social structures that enable humans to collaboratively pursue specific goals (Scott and Davis 2007: 11). According to Herbert Simon (1997) organizations have purposeful and rational designs that allow individuals to solve problems through collective efforts. The formalized structures that give shape to organizations also generate stable and predictable behaviors for the members that participate in organizations. However, the characteristic of repetitive, routine and predictable behaviors contradicts the organizations' need to adapt to changing circumstances. As Bryan Jones (2001) stated:

> *"The paradox of organizations is that they provide stability, thus allowing people to coordinate their actions to achieve their goals, but they also must be adaptable in the face of changing circumstances, thus disrupting the stability they provide." (p.4)*

As potentially open systems, organizations have the capacity to react to changes in the external environment by adjusting their operational strategies (Scott and Davis 2007). From the open system perspective, the behavior of an organization is not simply dominated by its formal structures. Rather, organizations can learn and adapt by adjusting their formal structures and

their informal practices to better fit the external environment. Therefore, collective action is fundamentally an issue of decision making. It associates with the ability of each organization to sense and recognize the dynamic situations that exist in an operational environment and to develop strategies that enable them to achieve their goals.

Different from regular public policy problems, the problems created by disasters are highly dynamic, complex and often beyond rational control. As Aaron Wildavsky (1988) indicated, under the circumstances of uncertainty and change, it is difficult to manage risk by predicting and preventing potential dangers before the damage is done. In his book, *Searching for Safety,* Aaron Wildavsky introduced the concept of resilience, which refers to "the capacity to cope with unanticipated dangers after they have become manifest, learning to bounce back" (1988: 77). Wildavsky suggests that an organizational system can increase its risk tolerance by developing the flexibility needed to adapt to a variety of situations. While formal structures may reduce unexpected organizational behaviors and transaction costs among organizational components, organizations that want to respond to changing environments must also have the capacity to effectively coordinate and manage collective activities.

1.2 PROBLEM STATEMENT

The goal of this research is to understand the formation of interorganizational networks under uncertain and emergent situations. This research is important because it is under such situations where the effective management and the collective action of organizations is the most critical. In extreme events, which are expansive in both time and space, emergency responders face the challenge of making decisions under the circumstance of unclear causality, interdependent

consequences, insufficient information, and constrained time. Due to the scale of impact and the nature of complexity, organizational actors from diverse backgrounds and different sectors usually become involved in emergency response activities. Therefore, it is important for us to understand how organizational actors react to uncertain and dynamic conditions, and how they interact with other organizations in the system.

This study presents a case study that examines the formation of interorganizational networks in emergency response situations after two disaster events in Taiwan: the Chichi Earthquake in 1999 and Typhoon Morakot in 2009. The study is organized around four problems. First, to identify the initial conditions that were present in the systems in which disaster response organizations emerged. The initial conditions in which organizations operate may largely influence the strategies that organizations will adopt. As Herbert Simon (1996: 11-12) stated: "[t]he outer environment determines the conditions for goal attainment…the inner system is adapted to the environment, so that its behavior will be determined in large part by the behavior of the latter."

Second, to examine the interactions exchanged among organizations within these two response systems. The formation of interlinking networks is a dynamic process that evolves over time. I map out the content and patterns of the interactions in the response systems, and identify the extent to which their network structures evolved. Third, I explore the factors that influenced organizational interaction. As the formation of interorganizational networks is a continuous decision making process that is implemented by individual organizations in the social system, this study aims to identify the factors that shaped the organizational decision making processes during the response periods.

Finally, I analyze the extent to which the studied systems changed after the disaster events. The experience of responding to disaster events can lead to change and adaptation in organizations. Organizations can learn and adjust their institutional structures accordingly. However, the presence of change in individual organizations does not mean that learning will occur at the social level. This study examines two disaster events that were separated by a ten-year interval. By analyzing the networks that formed after these two events, this study identifies whether the system learned, and whether the response network that formed after the second event differed from the response network that formed after the first event.

1.3 SIGNIFICANCE OF STUDY: CONTRIBUTING TO THE THEORETICAL AND PRACTICAL DEVELOPMENT OF NETWORK GOVERNANCE

Network governance, an alternative to hierarchy and market models, has been advocated as a response to growing social diversity, dynamics and complexity (Powell 1990; Koppenjan and Klijn 2004; Goldsmith and Eggers 2004). Scholars recognize that standard operating procedures, such as management through the chain of command or market competition, are no longer sufficient for solving complex social problems (Teisman and Klijn 2002). The network approach to governance suggests that no single authority can dominate the governance process, and emphasizes the interdependencies and interconnections that exist among organizations.

In a network system, the achievement of common organizational goals depends on the functional capacity of the governance networks that coordinate collective actions among the organizations in the network. Although network governance is widely discussed as an approach

that can be used to manage collective action and complex public policy issues, there is a lack of understanding of how governance networks develop and operate, especially in disaster contexts.

This study investigates the formation of two disaster response networks in Taiwan's disaster management system. More specifically, this study investigates how these response networks emerged and evolved during the three weeks that followed a major disaster. This study also explores how the formal structure and interaction process factors influenced the formation and operation of these response networks. The findings generated by this research will advance network governance theory by providing a better understanding on the dynamics of interorganizational network formation. While most governance theories focus on how to manage the governance network after it is formed, this study aims to further understand the circumstances that lead to forming networks and the conditions under which evolve.

An analysis of the emergency response in two disaster events, separated by an interval of ten years, is useful to examine change over time. This study examines the extent to which disaster management systems can change, and the extent to which changes within the first disaster management system influenced the formation of response network in second disaster management system. This study will also enhance understandings of disaster response systems among practitioners in Taiwan. Decision making and complex adaptive system theories provide an alternative perspective on what represents the critical structural and procedural factors that influence the formation of functional governance networks in emergency situations.

By identifying and mapping the disaster response network structures that emerged after the ChiChi Earthquake and Typhoon Morakot, this study also reveals the key actors, and the strengths and weaknesses of the interorganizational network structures that emerged during the immediate periods of disaster response. Typhoon Morakot tested the policy changes were

implemented between 1999 and 2009 in Taiwan's disaster management system. The results of this study will also reveal the effects of policy changes after the ChiChi Earthquake. The research will help policy makers improve the performance of Taiwan's disaster management system by maintaining existing relationships, strengthening connections among key actors, eliminating the gaps that exist between disaster response organizations, and strengthening the factors that promote collective action in uncertain conditions.

1.4 ORGANIZATION OF THE STUDY

This study consists of eight chapters. Chapter one states the research problems that drive this research. This chapter identifies why we need to enhance our understandings of the formation of interorganizational networks in uncertain situations, as well as the theoretical and practical significance of this research. Chapter two reviews the literature that contributes to our understanding of the research problem. This chapter starts by reviewing the network governance literature, emphasizing the interdependencies of social entities and the reasons why organizations would cross boundaries to work together. This study then moves towards the organizational level by reviewing the literature on decision making and the formation of interorganizational networks in conditions of uncertainty. Next, this study reviews the literature related to policy learning and adaption at the system level. Finally, the conceptual framework is proposed as the synthesis of the literatures reviewed. Chapter three describes the research design that is utilized to collect, process, and analyze the data related to this study. This chapter includes a justification of the case selection, the research questions that guide the study, the presentation of the unit of analysis, the research methods and analytical process, and a discussion on reliability and validity.

Chapters four through seven answer the research problems raised by the empirical study of the Chichi Earthquake in 1999 and Typhoon Morakot in 2009, both of which occurred in Taiwan. Chapter four presents the primary institutional, social, economic, and political environment as the initial conditions underlying the systems within which the studied response network formed. Chapter five identifies the organizational actors engaged in the core system and maps the response network structures that formed after the two events. This chapter also presents the observed networks using social network analysis measurements, evaluates the structural evolution of the networks, and categorizes the content of the interorganizational interactions. Chapter six analyzes the factors that influenced the formation of networks. This chapter provides the empirical evidence that explains how formal structural factors and informal process factors influenced the formation of the response networks. Chapter seven synthesizes the empirical findings and examines the policy changes that occurred in Taiwan's disaster management system after the Chichi Earthquake in 1999, and analyzes the extent to which Taiwan's disaster response system was resilient to disruptive disaster events. Chapter eight presents the findings and implications of this study. This chapter summarizes the findings to the proposed research problems, and offers policy recommendations that can be used to enhance the capacity of disaster response systems. Finally, the chapter brings the study to a conclusion by presenting possible avenues of future research.

2.0 INSIGHTS INTO THE FORMATION OF INTERORGANIZATIONAL NETWORKS

In uncertain and complex situations, public managers need to know how to coordinate and govern the collective actions performed by actors that pursue their own goals and strategies. Given the rise in catastrophic events around the world, this research suggests that enhancing the understandings of the formation of interorganizational networks in uncertain situations is the key to developing emergency response capacity. Meanwhile, it is critical to understand the extent to which the structure of disaster response systems can be adapted and improved to promote better future performance, without diminishing the flexibility that is the system needs to cope with uncertain situations.

This research is guided by three separate literatures. First, the network governance literature is reviewed to identify the challenges related to solving contemporary social problems. This literature also indicates that complexity comes from the interdependencies that exist among actors that come from different sectors and jurisdiction levels. This literature also indicates that no single organization can solve public problems without the assistance of other organizations. Second, the literature on decision making, as it relates to the formation of interorganizational networks, is reviewed. This literature suggests that interorganizational interactions help decision makers to solve problems in complex and uncertain situations. More importantly, the decision making literature provides us with insights into the factors that influence the formation of

interorganizational networks. Third, policy change literature enables us to understand the extent to which social systems can change and adapt after disaster events.

This chapter concludes with a synthesis of the three literatures reviewed. This synthesis is used to develop and propose a conceptual framework that presents the key elements, and the relationships among these elements, that are essential for analyzing the formation of interorganizational networks in uncertain situations.

2.1 CONCEPT OF NETWORK GOVERNANCE

2.1.1 Definition of Network Governance

As modern society became increasingly complex, dynamic and diverse, governance theorists began to recognize that government is no longer the only actor that can deal with public affairs (Kettl 1993; Kooiman 2003; Milward and Provan 2000; Rhodes 1997). According to Jan Kooiman (2003), governance is defined as "the totality of interactions, in which public as well as private actors participate, aimed at solving societal problems or creating societal opportunities; attending to the institutions as contexts for these governing interactions; and establishing a normative foundation for all those activities" (p. 4). This definition suggests that there are three key aspects of governance. First, governance is not a singular action, but a continuous process of collective action that involves multiple actors who repeatedly interact with each other. Second, the concept includes the notion of an intention, for example, to solve social problems or to create opportunities. In other words, governance is goal-driven activity that can bring a system from one state into another. Third, the analysis of governance contains two aspects: process and

structure. To analyze governance, researchers must not only investigate the decision making processes at work within a society, they must also investigate the normative structure within which all interactions and decisions occur. The processes and structures of governance are interdependent, meaning that the structures will affect the processes, and the processes will affect the structures.

Network governance has been advocated as a response to the public management problems created by ever-increasing societal diversity, dynamics and complexity (Agranoff 2007; Goldsmith and Eggers 2004; O'Toole 1997). The network approach to governance focuses on the patterns of social relationships that are developed among interdependent actors. These relationships tend to develop around public problems and the resources used to respond to public problems (Kickert, Klijn, and Koppenjan 1997). The network perspective provides a way to describe and analyze the interactions and relationships shared among multiple social actors from different sectors who operate according to different rules and goals. A functional network should be able to facilitate communication, mobilize resources, and coordinate collective action among the social actors that seek to move towards common goals.

2.1.2 Modes of Governance

Kooiman (2003) argues that there are three modes of governance in social systems: hierarchical governance, co-governance, and self-governance. Hierarchical governance refers to the interactions in social systems that contain a higher authority that is in some way superimposed above those that are governed (p.115). Co-governance refers to the various forms of co-arrangements that social entities use to achieve common goals. For example, collaboration and co-operation are two types of co-arrangements, commonly observed in co-governance practices,

which are embedded in contemporary social systems (p. 96). Built upon the concept of autopoiesis, self-governance refers to the capacity of social entities to provide the means necessary to develop and maintain their own identity, and to show that they possess a high degree of autonomy and adaptability (Kooiman 2003; Luhmann 1995). While each of these three governance modes is useful as an organizing concept, they are limited in that they only partially capture the various types of interactions that are exchanged in social systems. In other words, societies do not rely on a single governance mode.

In modern society, governance is actually a mixture of the three governance modes discussed above. For example, in a disaster response system, government agencies may operate with hierarchical and legal authority to mobilize resources within the governance system. The government also collaborates with nonprofit and private organizations to provide services to those affected by disaster. In addition, citizens can also self-organize, as they search for relief assistance and work to reduce uncertainty.

2.1.3 Motives that Make Organizations Work Together Across Boundaries

The building of interorganizational relationships across boundaries is a common phenomenon in modern society. To understand the formation of interorganizational networks we must learn why organizations work with other organizations, both within and across sectors or jurisdictions. For this, we can turn to literatures on the topics of public private partnerships, cross-sectoral collaboration, and inter-governmental relationships. Each of these three literatures discusses the reasons why organizations may seek to develop interorganizational networks.

The research on intergovernmental relationships focuses on interactions exchanged among governmental agencies at different jurisdiction levels. Although the interactions

exchanged among government organizations are often influenced by hierarchical structure, there are scholars that view intergovernmental relationships as a network setting that requires the collaboration and coordination that extends beyond hierarchical control (Agranoff and McGuire 1998a; Milward and Provan 2000; O'Toole and Meier 2004). The purposes and motives of building cross-sectoral relationships were also widely studied as the topic of public-private and public-nonprofit partnerships. Most researchers have used resource dependence theory, institutional theory, and transaction theory to analyze cross-sectoral collaboration, and they have concluded that resources, efficiency, effectiveness, and legitimacy are the major motives that make organizations work with each other across boundaries (Das and Teng 2000; Gazley and Brudney 2007; Guo and Acar 2005; Young 2000; McQuaid 2000).

On the basis of the predictive contingencies of interorganizational relationship formation proposed by Christine Oliver (1990), this study discusses five motives of building interorganizational relationships: necessity, resources, effectiveness and efficiency, stability and legitimacy.

(1) Necessity: An organization may interact with other organizations under the legal or regulatory requirements. For example, local government agencies are required to submit situation reports to higher authorities when responding to disaster events.

(2) Resources: Organizations may build linkages with others to secure desired resources or to reduce competition for resources (Das and Teng 2000; Gazley and Brudney 2007; Guo and Acar 2005; McQuaid 2000). According to Oliver (1990), such organizational relationships could be built upon the asymmetry of power or a reciprocal exchange upon mutual agreements. However, the desire for resources is the core reason to engage in such transactions.

(3) Efficiency and Effectiveness: Organizations may build relationships to achieve higher levels of performance (Gazley and Brudney 2007; O'Toole and Meier 2004). On the basis of transaction theory, initiating collaboration with other organizations is a result of a rational calculation of transaction costs. The partnership may increase operational efficiency by reducing the time needed to complete interorganizational negotiations.

(4) Stability: Organizations may build linkages or relationships with other organizations to reduce uncertainty. For example, O'Toole and Meier (O'Toole and Meier 2003) found that school districts might build networks to maintain stability in personnel.

(5) Legitimacy: Organizations may build linkages with other organizations to enhance their reputation, image, or prestige. Organizations also have the need to fulfill social norms and social expectations. For example, to fulfill what they believe to be a social responsibility, private companies may sponsor nonprofit organizations. Also, national policy makers may invite local community and stakeholders to attend the meetings to enhance the legitimacy of the decision making process (McQuaid 2000).

2.2 DECISION MAKING AND THE FORMATION OF INTERORGANIZATIONAL NETWORKS IN CONDITIONS OF UNCERTAINTY

This research views the formation of networks as a continuous decision making process that is employed by organizations to solve problems in dynamic and uncertain environments such as those present in disaster response situations. This section reviews literatures that identify the sources of the uncertainties that organizations face when making decisions (Koppenjan and Klijn 2004). Next, complex adaptive system theory (Axelrod and Cohen 2000) is examined to explain

how actors adapt to changing environments by interacting with other actors in the system. On the basis of complex adaptive system theory, this research discusses the four reasons why organizations make decisions to interact during disaster response situations: cognition, communication, coordination and control (Comfort 2007).

2.2.1 Uncertainties that Decision Makers Face

After a process of decision making, organizations may elect to interact with other organizations to solve certain problems and to achieve certain goals. The performance of problem solving depends on the match between the nature of tasks and the capacity of those attempting to complete the tasks. With the traditional rational decision making approach, organizations make decisions through the processes of collecting data, analyzing, evaluating options and choosing the best solution. The rational decision making approach assumes that organizations deal with static problems with complete information in a closed system (Simon 1997; Thomson 1967).

In reality, most public problems faced by disaster management organizations are complicated and ill-structured. Moreover, the capacity of organizational decision makers is limited by the principles of bounded rationality (Simon, 1997), and as Joop Koppenjan and Erik-Hans Klijn (2004) observe, given that the social environment is full of uncertainties, organizations often operate in the social environment as interdependent actors. Organizations face a variety of substantive, strategic and institutional uncertainties when they deal with complex problems in a networked environment. First, there is the substantive uncertainty related to the availability of information, knowledge and the interpretation of the meaning of information. Decision makers simply cannot make adequate decisions without quality information and knowledge. Second, strategic uncertainty can increase the complexity of

decision making. In attempting to solve a problem, each of the actors in a network can develop different response strategies based on their own interpretation on information during the interaction process. The limited predictability on other actors' strategies increases the uncertainty of decision making processes. Third, actors in the network usually work from different institutional backgrounds, and their behaviors are guided by rules and culture from their own organizations. This institutional uncertainty can increase the difficulty of dealing with complex problems in a network.

2.2.2 Formation of Networks and Complex Adaptive System Theory

Governance is a dynamic balancing process that operates in complex, dynamic, and diverse environments. Responding to public problems is not a singular action, but a continuous process of reaching the equilibrium between resources and needs within a system. The actors in a governance network keep adapting to establish a balance between structure and process, and in doing so, they work to address the tensions that are inherent in the network. Although the constant interaction between actors and the structural environments are recognized in the governance literatures, the literature is inconclusive about when and how organizational actors adapt to the environment. The theoretical model of complex adaptive systems offers a perspective for understanding how a social system, such as a governance network, adapts in rapidly evolving environments (Axelrod and Cohen 2000; Comfort 1999).

In their book, *Harnessing Complexity*, Robert Axelrod and Michael Cohen proposed the complex adaptive system framework, which can be summarized as:

> *"Agents, of a variety of types, use their strategies, in patterned interaction, with each other and with artifacts. Performance measures on the resulting events drive the selection of agents and/or strategies through processes of error-prone copying*

and recombination, thus changing the frequencies of the types within the system" (2000: 154).

According to Axelrod and Cohen, the formation of networks in a social system is the result of the strategic choices that organizations make to adapt to the changing environment. The social actors in the system are varied in terms of their mission, stock of resources, comparative advantages, and the operational rules and strategies used for surviving. These variations create complexity within systems. The events in the system drive the processes of selection and help social actors to identify successful strategies and interaction patterns.

Complex adaptive system theory provides insights into the formation of interorganizational networks. First, the complexity of the social system comes from the variety of strategies that actors may adopt to respond to the surrounding environment (Axelrod and Cohen 2000: 11). It is hard to make predictions in complex settings because all of the actors in the system may try to achieve their own goals using their own strategies, and these strategies may change over time. Second, interaction is the key activity in the system, which allows the actors to spread and receive information and resources. In such a situation, actor and system adaptation becomes possible (p. 62). Third, interactions exchanged among actors are influenced by geographical distance and conceptual space. Physical distance and conceptual space, such as group affiliations and social classes, determine which actors are likely to interact, to spread out the information, and to share resources (p. 68). Fourth, complex systems can evolve and adapt through the process of selection. The performance of actors and strategies in the system are evaluated, and those who meet the criteria of success stay in the system. The actors will adapt and learn strategies to survive. Collectively, the system evolves (p. 117).

2.2.3 Processes of Forming Interorganizational Networks

According to complex adaptive system theory (Axelrod and Cohen 2000), interaction is key for complex systems, which allows information and resources to flow among the various actors and activate the evolution and adaptation of the system. Through recurring interactions, the actors in a network collect information, adjust strategies, and develop institutions that help them to reduce uncertainties (p. 62).

Forming an effective interorganizational network, in which various types of actors can share knowledge and resources to pursue a common goal, is critical to the success of an emergency response system. Comfort (2007) identified four key components related to the formation of an effective interorganizational emergency management network: cognition, communication, coordination, and control. In short, cognition is needed to activate the other three components in emergency management system. Communication, coordination, and control are the strategies that organizations adopt to secure access to the resources and information needed to achieve their goals.

2.2.3.1 Cognition

According to Comfort (2007), cognition in public governance is "a process of continuing inquiry, building on prior knowledge of the region at risk and integrating incoming information on changing conditions and system performance into a current assessment of vulnerability of the community (p. 193-194)." Under conditions of uncertainty, cognition is the key element that triggers individuals to react or initiate collective actions to respond to the environmental change (Comfort 2007; Hutchins 1995; Weick 1995, 1993). With limited information, decision makers in emergent situations do not follow traditional decision making processes to choose the best

solution to a problem. Rather, they usually only react to the discrepancies or the malfunctions that they detect based on their previous experience and knowledge. According to Hutchins (1995), cognition is a social and cultural process that is influenced by organizational structures, rules, and cultures. Hurricane Katrina, which struck the United States in 2005, provides an example of the importance of cognition in intergovernmental emergency management. Without recognizing the severity of the threat, decision makers failed to take timely action to prepare for, and to respond to, the disaster (Comfort 2007).

2.2.3.2 Communication

The resolution of most public problems requires the engagement of multiple actors. This is because individual government agencies do not have the knowledge, information, and resources needed to solve the problems. Communication is therefore essential to build a "common operating picture" among organizations that operate in a network (Comfort 2007). Disaster response networks, for example, are composed of organizations from various jurisdictions and sectors. Each organization sits in a different location, and has different goals, functions, cultures, level of resources, and rates of adaptation (Drabek 1994). A sufficient level of shared information among organizations is critical to enable each organization to identify potential constraints and opportunities, and to make cooperation among organizations possible.

Information and communication technology can also influence the interaction patterns among organizations in a governance network. Information technology, as the communications infrastructure, is critical to managing the complex, dynamic operations that evolve in uncertain environments (Comfort and Haase 2006). For example, information and communication technology improve the speed and quality of decision making by increasing the availability of timely and accurate information that is critical for identifying problems and opportunities (Huber

1991). Organizations can employ a variety of tools to exchange information, for instance, radios, cell phones, landline and satellite telephone networks, and the Internet.

2.2.3.3 Coordination

Coordination can occur when entities link their resources and processes together to achieve certain outcomes. As effective communication depends on cognition, effective coordination depends on communication. Without shared understanding through effective communication, it is less likely a diverse collection of organizations would work together voluntarily to achieve a common goal in a governance network.

According to Chisholm (1989: 10), coordination can be programmed as a formal and centralized structure, but such forms of coordination can only work in stable and predictable environments. Formal coordination, such as hierarchical structure that is designed to achieve certain goals with particular assumptions about the operating conditions, may not function as planned in highly uncertain disaster response situations. As Simon (1997) indicated, formal coordination is the result of three steps: 1) a developed plan of action; 2) communication of the plan of action to the actors who will carry it out; and 3) acceptance of the developed and communicated plan by all actors. It would be difficult to have a formal coordination plan accepted by all of the actors in the disaster environment, since there are usually new and unexpected tasks and actors that emerge after the disaster event occurs (Drabek 1994: 31).

In contrast, informal coordination tends to be flexible and adaptive. Informal systems are loosely coupled and self-organizing in the sense that they respond to problems as they arise, rather than to the pre-assigned tasks (Chisholm 1989). By utilizing a flatter and more flexible coordination structure, organizational actors can quickly exchange information and resources. Nevertheless, there are also weaknesses in systems that utilize informal coordination techniques.

Informal coordination, which is built upon informal agreements among actors, may fail due to the lack of enforcement and accountability. Without legal protections, actors may need to spend time to build trust before they decide to coordinate. Chisholm suggests that a hybrid system, in which a formal organization with carefully designed functions is introduced into an informal network, may be a solution for an effective coordination.

2.2.3.4 Control

The concept of control usually implies the exercise of power over members of an organization by the higher authority. However, as Comfort (2007) stated, in the environment of disaster response, control means "to keep actions focused on the shared goal of protecting lives, property, and maintaining continuity of operations […] through shared knowledge, commonly acquired skills, and reciprocal adjustment of actions to fit the requirements of the evolving situation" (p. 195).

Traditionally, the government is regarded as the authority that mobilizes resources to respond to the needs of the public. However, in highly uncertain and emergent situations, government agencies may lose control of their capacity to coordinate collective action among various social entities. For example, right after a disaster strikes, the impact area requires massive amounts of response personnel, equipment, and supplies. The government is not the only agency that possesses the necessary resources. In fact, the government may need to rely on contributions from nonprofit and private organizations to provide relief assistance to the victims. This means that in a disaster response system, the power of control is distributed across the organizations that possess the resources and information needed by those in the network (Pfeffer and Salancik 2003). With a shared common goal, these organizations could self-organize and build the interorganizational relationships needed to achieve the common goal.

2.2.4 Factors that Influence the Formation of Networks

As Axelrod and Cohen (2000) indicated, the actors in a complex system have their own routines and strategies of choosing with whom to interact. This section discusses the factors that influence whether an organization decides to build linkages with the other organizations in a complex setting. First, this research focuses on the role of institutions that represent the normative requirements of appropriateness, legitimacy, and procedures that guide the social actors' behaviors. Second, the importance of information and communication technology in forming interorganizational networks is addressed. Third, this research adopts the socio-technical approach to discuss the role of social relationships in forming interorganizational networks in the situation of disaster response.

2.2.4.1 Institutions

According to Elinor Ostrom (2005: 51), institutions are defined as "sets of working rules that are used to determine who is eligible to make decisions in some arena, what actions are allowed or constrained, what aggregation rules will be used, what procedures must be followed, what information must or must not be provided, and what payoffs will be assigned to individuals dependent on their actions." Institutions do not just represent formal structure. For March and Olsen (1984), institutions can be understood as a collection of norms, rules, and routines.

A legal institution is a set of formal rules that contain prescriptions that forbid, permit, or require some action or outcome, which affects individuals making the decisions on the action they will take. Legal institutions affect the governance of organizational networks in disaster response system in different ways. For example, legal institutions may facilitate interaction among actors in the system by lowering transaction costs (Coase 1937; Williamson 1981),

encouraging cooperation, and reducing uncertainty. However, inadequate institutions may also constrain responders from taking prompt action. As the disaster response system may not have fully prepared for extreme events, the specific responsibilities of each organization may not be well defined. Finally, the lack of legitimacy may also constrain communication and coordination among organizations (Handmer and Dovers 2007).

Informal rules such as norms and routines, though not written in law, also influence the behavior of actors in a social system. Norms are built through repeated interactions among individual and social entities, which may also evolve separately in the interaction process (Ostrom 2000). Some researchers have indicated that norms play a role in organizational behavior during disaster response situations. For example, Schneider (1995) suggested that governmental disaster response processes are driven by the bureaucratic norms that influence the government's performance of addressing the emergent situations in context of disaster events. Bharosa, Lee, and Janssen (2010) also found that the organizational norm is one of the factors that influence an organization's attitude toward information sharing in disaster response situations.

2.2.4.2 Information and Communication Technology

Information sharing among participants in disaster response networks is critical (Bharosa, Lee, and Janssen 2010; Comfort, Ko, and Zagorecki 2004). In disaster response situations, there are multiple groups that need to collaborate to solve problems. The lack of information sharing among responders will impede collective decision making for effective action. Information is essential for decision makers to accurately assess damage, effectively allocate resources to meet needs, and establish priorities for the implementation of tasks.

Information transmission, data processing, and storage are constrained by geographical distance and the limited physical and cognitive capacity of human beings. Information communication technology (ICT) that consists of telecommunication and computer hardware, software, and information storage systems can enhance the performance of human beings through the processing, transmission, and storage of information. The advancement of ICT allows organizations to share information simultaneously with multiple actors within a short period of time, regardless of geographical distance. There is also research that indicates that ICT may enhance information sharing and decision making among organizations (Graves 2004, cited by Bharosa, Lee, and Janssen 2010), and reshape the way that organizations interact (Holland and Lockett 1997; Lipparini and Sobrero 1997; Lütz 1997).

However, information is not sufficient to solve the problems confronted by governance networks. In *Knowledge Management in the Sociotechnical World: The Graffiti Continues*, the authors apply the socio-technical approach to examine knowledge management in organizations (Coakes, Willis, and Clarke 2002). Rather than only seeing information technology as technical artifact, the socio-technical approach "highlights the importance of the interplay between the social aspects of an organization and the technological infrastructure, forming a means by which new knowledge assets can be created, shared and communicated" (Coakes, Willis, and Clarke 2002: 3). Information and communication technology are tools and resources that the managers can apply to facilitate effective interaction patterns among organizations and govern organizational networks. According to the socio-technical perspective, network managers should not only focus on the use of information technology, but they also need to consider: (1) whether the organizations in the system have suitable human resources to operate the technology and (2)

whether the communication loops are well designed so that the organizations in the system can effectively use technology to collect essential problem solving information.

2.2.4.3 Socio-Technical Capital

Based on observations of Italian society, Robert Putnam (1994) proposed the concept of social capital to indicate how social relationships facilitate cooperation and coordination among social entities, and enhance the efficiency of collective action. Research has shown the effects of social networks and trust on the formation of interorganizational networks and the use of resources that are embedded in the social relationships (Adler and Kwon 2002; Burt 1992; Coleman 1988; Guo and Acar 2005). For example, Anna Dubois and Hakan Hakansson (1997) suggest that the formation of interorganizational relationships not only depends on the properties of resources exchanged, but also on the history of the relationship, and the nature and density of the linkages that the organizations might possess. Mark Casson and Howard Cox (1997) argue that social networks create an invisible infrastructure of social bonds among actors, which have positive effects on the interorganizational networking.

Although scholars have suggested that social capital plays an important role in disaster management (Nakagawa and Shaw 2004), this research found the concept of social capital has its limits when it comes to disaster response situations. An individual must be able to connect to others to reach and utilize the social capital embedded in social relationships. However, disasters usually disrupt infrastructure such as electrical facilities, communication and transportation systems (Comfort, Ko, and Zagorecki 2004). When the Internet is disconnected, phone lines and cellphone systems are also damaged, radio channels can become overloaded, and the transportation system can fail. Consequently, the communities that are impacted by the disaster

can lose all means to reach and communicate with others. This means that people cannot utilize the resources in their social networks because they have become isolated.

The concept of *socio-technical capital* may be more adequate for analyzing the formation of interorganizational networks in disaster response contexts. Social technical capital emphasizes the capacity of a system to utilize information and communication technology (ICT) to build linkages with other organizations and to activate the resources in the network. The advancement of ICT helps us to overcome the barriers of geographical distance for interaction (Axelrod and Cohen 2000), allowing people to interact and build connections without having to get together physically. Through certain ICT, such as cyberspace forums or online social media, the history of interactions and the shared knowledge can be automatically stored and easily retrieved. Therefore, collective knowledge can be accumulated and shared across a longer period of time, and other participants, who enter the system at later points in time, can access the knowledge stored in the system (Van den Hooff, de Ridder, and Aukema 2004).

From the socio-technical capital perspective, the formation of interorganizational networks are influenced by the extent to which organizations can secure the means of communication to activate resources in their social networks. This perspective implies two elements to networking in disaster response situations: (1) maintaining the accessibility and connectivity during emergency situations, and (2) build well-informed and knowledgeable social networks that could be activated in the situation of disaster response.

First, individuals or organizations must be able to secure the channels to communicate to the other actors in the network, and to acquire and allocate assistance and resources throughout the network. Given the disruptions and uncertainties that disasters may cause, organizations need to have the capacity to access and utilize multiple means of communication. Second,

organizations need to accumulate social capital in their social relationship networks by engaging in repeated interactions with other organizations during normal situations. Organizations can build social networks that enable the actors to become aware of risk and to share collective knowledge about how to respond to disaster situations. By using ICTs, this social network can be built beyond the barrier of geographical distance and conceptual space. Once a disaster occurs, the well-informed actors in the network will possess shared intellectual capital and will be able to self-organize and react to the emergency situation rapidly while communication is limited.

2.3 POLICY CHANGE AFTER FOCUSING EVENTS

According to Thomas Birkland (2010), public policy is "a statement by government of what it intends to do about a public problem (p. 9)." Policies take many different forms. These forms include laws, regulations, court decisions, agency or leadership decisions, or changes in the behavior of government officials at all levels. It is important to understand disaster management when analyzing the formation of a disaster response network. This is because government agencies are the major actors in a disaster response network, and the design of disaster management policy will influence the behavior of other non-public actors. In short, policy is an institutional structure that influences the operational function of the actors in the system.

Disasters that cause significant damage can become a focusing event that draws the attention of the public. Through the destruction of critical infrastructure and loss of property, disaster events reveal the discrepancy between the design of a disaster management system and the system in practice. As the evidence of policy failure becomes apparent, governments can be pressured to promote certain disaster management policies to fix the problems in disaster

management policy. It is critical to understand the extent to which the policy can change and adapt with the goal of improving the system for avoiding more damage from the future disaster events. This section looks at how the literature discusses the relationships between focusing events and policy change.

2.3.1 Focusing Events and Agenda Setting

According to Thomas Birkland (1997), a focusing event is: "an event that is sudden, relatively rare, can be reasonably defined as harmful or revealing the possibility of potentially greater future harms, inflicts harms or suggests potential harms that are or could be concentrated on a definable geographical area or community of interest, and that is known to policy makers and the public virtually simultaneously (p. 22)." Focusing events, such as natural disasters that cause significant damage, are rare but reveal the discrepancy between a disaster management system's designed structure and its actual performance in practice (Comfort 2006). When a large event occurs, the scenes, photos and stories of damages and victims are distributed widely via mass media. People pay attention to the event, discuss the event, and want to know how to avoid similar events in the future.

The way the society perceives a problem and identifies the cause of a problem influences the conclusion of who is responsible for the failure and addressing the damage that occurred. This is because events such as natural disasters are socially constructed (Birkland 1997; Stone 1989). For example, if a natural disaster is considered as an "act of God," people may accept it and pay sympathy to the victims. However, if the focusing event is considered the result of poor design of building structures, lack of appropriate management, or corruption in the administrative system, people will blame the individuals or entities responsible for the damage

and expect action to be taken to prevent the future harms. The social construction process identifies why a problem is a problem, whose fault it is, and how it can be solved. Based on the multiple stream model proposed by John Kingdon (1995), Birkland (1997) studied how the focusing events influence agenda setting within a political system. Birkland indicates that the problems revealed by focusing events are not simply objective problems. His research emphasizes the role of news media in framing and propagating focusing events, which influence the political and social participants to define the nature of problems and generate acceptable solutions in the agenda setting process.

Agenda setting is a key policy making activity (Birkland 1997), but public attention or setting of the agenda does not necessary lead to policy changes. The agenda is "a collection of problems, understandings of causes, symbols, solutions, and other elements of public problems that come to the attention of members of the public and their governmental officials" (Birkland 1997: 8). There are many agendas under discussion at all levels of government. When certain issues or problems gain attention, they can be placed on the agenda. The agenda item may then be placed on the institutional agenda, where solutions to the problem will be discussed and the preferred option may become institutional statements (Birkland 1997: 9). Kingdon (1995) suggests policy change occurs when elements of three streams, problem, policy, and politics, come together to meet in a "window of opportunity." When an issue gains agenda status, alternative solutions are selected, and the political support emerges, then a window of opportunity for policy change may open. Each of these three streams contains various individual, groups, and organizations that are involved in the policy-making process. The involved entities may then compete or cooperate to promote the preferred agenda or to prevent the issues that are against their interests. Therefore, focusing events may gain attention and

promote certain issues into agenda, but they do not guarantee that a substantial change in policy will occur.

2.3.2 Knowledge, Learning and Policy Change

Policy learning is a desirable goal for policy analysis. Through policy debating, and learning from experiences, public policy may evolve and improve (May 1992; Lindblom 1990). It is believed that policy can change because individuals learn (Busenberg 2001; Birkland 2006). Individuals make decisions using bounded rationality (Simon 1983), which means that individuals have limited capacity to gather and analyze information while solving problems. Given that policy problems are often highly complex, policy makers are usually not equipped with all the knowledge and information that is needed to make well-informed decisions. Since human beings are goal driven and problem solving oriented, people tend to solve problems and make better decisions over time (Simon 1997). When there is new information and knowledge available, people have the capacity to utilize the new information to correct and learn from errors (Birkland 2006; Busenberg 2001). Collectively, organizations and the policy system in which individuals operate can change and adapt.

Focusing events, such as disasters, often reveal problems to the public and decision makers. While experiences may bring new knowledge or better understandings about policy problems or the effects of policy instruments, this does not guarantee that policy learning or adaptation will occur. As May (1992) stated, learning implies ”improved understanding, as reflected by an ability to draw lessons about policy problems, objectives, or interventions,” which is different from copying or mimicking behaviors (p. 333). The change of policy may just simply be the result of copying or mimicking rather than the deliberated decision based on

systematic policy evaluation. In some cases, policy change did not occur because the event did not yield sufficient pressure for change (Birkland 2006: 169).

Policies change occurs in a variety of ways, and there are various categories of policy learning. When analyzing policy learning, we need to address the question of "who learns", "what is learned" and "what is the effect" of the learning. Scholars have discussed the concept of policy learning from different perspectives (Etheredge 1981; Hall 1988; Heclo 1978; Ross 1991; Sabatier 1988; cited by Bennett and Howlett 1992). Bennett and Howlett (1992) and Birkland (2006) synthesized the findings of these researchers and identified four types of policy learning. As Table 1 indicates, the four types of learning include government learning, lesson-drawing, social learning and political learning. First, learning can occur inside government organizations. The officials in government agencies can learn and adapt administrative processes when implementing polices. Second, the actors in a policy network can activate policy change. Interest groups may learn and advocate that government agencies adopt new programs or change policy instruments. Third, the policy change may be observed as a change in policy arguments. Politicians may learn and adapt their strategies in policy debates on the basis of new knowledge. Fourth, policy change is the change in the belief systems of the policy community (Sabatier 1988). According to Sabatier (1999), learning is a "relatively enduring alteration of thoughts and behavioral intentions that result from experience…(p. 123)." The deep core beliefs of the policy community may learn and adapt as the environment changes over a relatively long timespan.

Distinguishing between different types of learning helps us to understand the complex process of policy learning. However, no one type of learning can fully describe the policy learning processes that occur after disaster events (Birkland 2006). Policy learning is a multiple-

tiered phenomenon that coexists in social systems (Bennett and Howlett 1992). A focusing event may inspire different types of learning in the short and long term.

Table 1 Types of Learning

Learning Type	Who Learns	Learns What	To What Effect
Government learning	State officials	Process related	Organizational change
Lesson drawing	Policy networks	Instruments	Program change
Social learning	Policy communities	Ideas	Paradigm shift
Political learning	Political actors	Strategies	Improved arguments for particular policies

Source: Birkland (2006: 12)

2.3.3 Empirical Study on Policy Change after Focusing Events

Focusing events are important triggers for policy change because they provide evidence of policy failure (Birkland 2006; May 1992). Evidence of policy failure serves as a clear guide for policy learning. May (1992) conducted an empirical study on the connection between policy failure and policy learning, and indicated that policy failure may trigger three different types of learning: instrumental policy learning, social policy learning, and political learning.

In his book *Lessons of Disaster: Policy Change after Catastrophic Events*, Thomas Birkland (2006) considers whether, and to what extent, policy change follows a disaster event. Birkland examined three policy domains: homeland security, aviation security, and natural disasters including earthquakes and hurricanes, and proposed a model to investigate the policy change after focusing events. The model suggests that when a focusing event occurs, the increase of mass media coverage draws agenda attention, groups are mobilized, then ideas are discussed, and the ideas are adopted into policy change process (p.18). In his research, Birkland uses (1)

news media coverage, (2) interest groups' appearances at congressional hearings, (3) the substance of Congressional hearings, and (4) proposed and enacted legislation and regulations as evidence of policy change.

This empirical study provided valuable knowledge about the policy change after focusing events. First, the study shows that a few large and significant events are more likely to draw attention then several small events (p. 161). Second, in most cases, focusing events only triggered the mobilization among a narrow range of actors. The wide range of group mobilization did not occur after focusing events. People may assume that there would be a larger scale of group mobilization after catastrophic events. However, the results show, similar to the traditional policy domains, that only a small number of interest groups mobilized after focusing events (p. 164-165).

Third, there is a relationship between ideas and policy changes. Changes are more likely to happen when the ideas are triggered by the events. However, the author found that most of the policy ideas were not new. Disaster events did not lead to policy innovation. Focusing events only revamped pre-existing policy ideas. This finding is consistent with Kingdon's (1995) argument that the focusing events open the policy window to allow those pre-existing policy problems and solutions coupled together. Fourth, the study shows that policy change can be a long term and accumulated process (Busenberg 2001). Some events didn't yield policy changes, but the accumulation of knowledge takes place over time. As Birkland stated (2006),

> *"In essence, learning is a day-to-day activity, but it does not often change the core of an individual's or interest group's belief system. Larger systemic shocks - larger than just a focusing event by itself - are required, […] These major shifts are not the result of one event, but are often driven by a combination of related events (p. 14-15)."*

Birkland's research has provided important insights into the dynamic relationship between focusing events and policy change. However, there are limitations with the research. First, this study only used legal regulations as evidence of policy change, and missed the policy learning that takes place in other forms, such as adapting standard operating procedures in government agencies or knowledge improvement of street-level bureaucrats. In disaster response situations, standard operating procedures are critical for guiding the emergency response activities of organizations, and the cognition of first line responders is needed to ensure that effective action can be taken to solve emergent problems (Weick 1993).

Second, Birkland's study did not take the learning that occurred in non-governmental actors into consideration. Emergency response usually requires the involvement of non-governmental organizations, such as non-for-profit search and rescue teams, and the social service support from nonprofit and private organizations. As a catastrophic event may destroy the response capacity of local government agencies before support from higher jurisdiction levels arrives, local emergency response activities are primarily carried out by local non-governmental organizations. Therefore, the learning capacity of non-governmental organizations can be critical to the performance of disaster response system.

2.4 INTEGRATED CONCEPTUAL FRAMEWORK

This research integrates the theoretical concepts outlined above, and proposes a framework to identify the key elements and the relationships among these elements that one needs to consider when analyzing the formation of interorganizational networks under conditions of uncertainty. The structure of the framework is adapted from the Institutional Analysis and Development

(IAD) framework proposed by Elinor Ostrom (2005). This framework, revealed in Figure 1, presents the dynamic of the problem solving process and the adaptation of disaster response systems in the long term.

The *initial conditions* are the pre-existing features of the environment that existed in the system in which the disaster responders operate. These features include the institutional environment, social and economic vulnerability, and political environment within the community. The *focusing events* are the sudden and rare events that cause harm or suggest potential harm to the community of interests. In this research, disasters are considered focusing events because they usually trigger a wide range of actors in society. When a disaster event occurs, the *action arena* is formed in which variety types of *actors* participate and interact to the others in disaster response situation. The formation of networks is a continuous decision making process employed by actors to respond to the emergent *action situations*.

These network forming processes are also influenced by a set of *exogenous variables*, including: (1) institutions, (2) information and communication technology, and (3) the attributes of actors. These exogenous variables generate the structural and procedural influences on the formation of interorganizational networks. First, formal institutions, such as laws and regulations, mandate many of the interactions exchanged among actors in the disaster response system. Formal institutions serve as a structural factor that frames the pattern of interactions among actors. Informal institutions, such as norms, and routines also affect with whom actors would interact. These factors present their influences in the interaction processes.

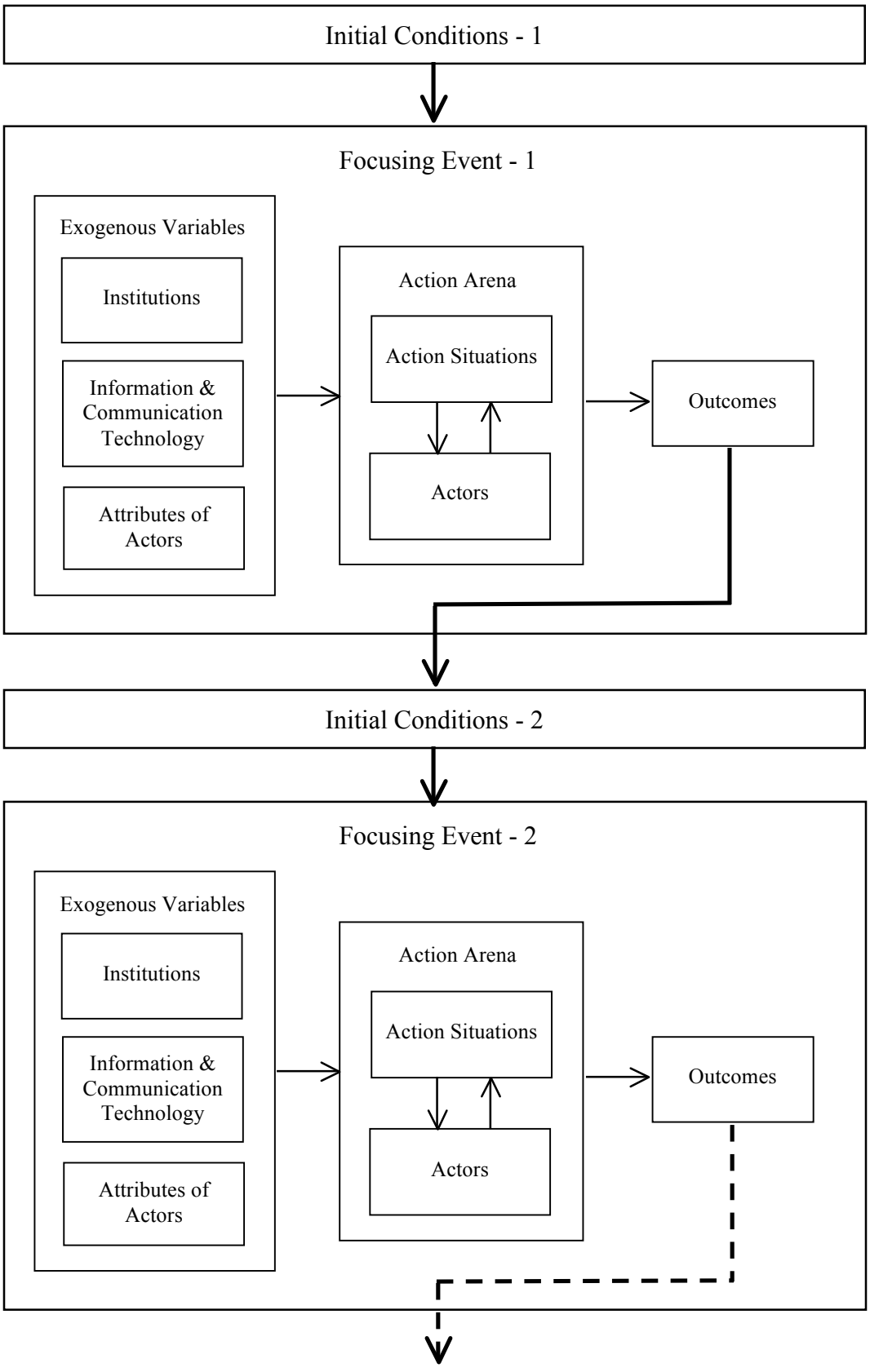


Figure 1 Conceptual Framework

Second, information and communication technology also generate structural and process factors. The hardware and the equipment available for the actors that respond to disasters are considered a structure factor that influences the pattern of interorganizational interactions. Meanwhile, the way that information and communication technology are utilized among actors is considered as the process factor that shapes network formation.

Third, a disaster response system often consists of varied organizations that operate within various jurisdiction levels and sectors. The attributes of these varied actors are presented as the structural factor that influences the actors' decision on building linkages with the others. The social relationships that are embedded in these varied actors also play a role in the process of forming interorganizational networks.

Focusing events that draw the public attention and provide collective learning experiences among the actors can trigger policy learning and policy change, which are considered the *outcomes*. The problem solving process often reveals the limitations of the disaster response system, and the policy adaptation and policy change may be implemented after the event. The adaption of policies will reshape the disaster response system and the features of the initial conditions that are present during subsequent focusing events.

3.0 RESEARCH DESIGN

This is an exploratory study that examines the formation of interorganizational networks engaged in the response activities of two disaster events: the ChiChi Earthquake of 1999 and the Typhoon Morakot of 2009. Based upon ideas drawn from literatures on network governance, institutional analysis and development, complex adaptive systems theory and policy change, this research views the formation of interorganizational networks in disaster response situations as a dynamic process of collective action that involves multiple actors that operate within nested institutional structures. The interactions exchanged among those actors are influenced by various environmental, structural and procedural factors, and the outcomes generated through these interactions become the inputs of the disaster response system for the later disaster events.

This research employed multiple methods to investigate this complex and dynamic phenomenon in the real world. The conceptual framework that guided this research will help me to identify the foundations at work within interorganizational networks and probe the relationships that exist among organizations within these networks. The empirical study is conducted on two disaster events, the ChiChi Earthquake in 1999 and Typhoon Morakot in 2009 in Taiwan. In this chapter, I will describe the design that was employed to explore the formation and adaptation of interorganizational networks that operate in disaster response situations.

3.1 NESTED CASE STUDY

This research employs a nested case study design to investigate the interactions that occur in multilevel complex systems (Huggins 2007; Haase 2009; Kamolvej 2006; Ostrom 2005). The nested case design differs from the contemporary case study design suggested by Yin (2003), which views units of analysis as distinct and independent entities (Haase 2009). In contrast, the nested cast study design considers the units of analysis in a complex system as non-distinct and mutually supporting entities (Haase 2009). According to Ostrom (2005), individuals interact with each other within institutional structures that include multiple components in many layers:

> *"Building on top of the single individual are structures composed of multiple individuals — families, firms, industries, nations, and many other units — themselves composed of many parts and, in turn, parts of still larger structures. What is a whole system at one level is a part of a system at another level (p. 11)."*

To understand the collective actions that occur within human societies, we need to recognize that such actions occur in nested institutional settings. In disaster response situations, organizations operate in an arena that is composed of several institutions and multiple layers. Emergency responders may interact with other participants in action arenas, and the external environment and nested institutional settings influence their actions. The actions will generate certain outcomes that work as inputs to change the environment and its institutions.

This research adopts the nested institutional structure perspective to investigate the interorganizational network that formed after two separate natural disasters. To get an accurate description of these systems, which were composed by non-distinct and mutually supporting components, this study collected data related to the interactions among the public, non-for-profit, and private organizations that operated at the national, county and municipal levels. Meanwhile,

given that the two events occurred across an interval of ten years, this study also catches the temporal dynamics that took place within Taiwan's disaster management system.

3.2 SELECTED CASES

Through the examination of two disaster response cases, the ChiChi Earthquake in 1999 and Typhoon Morakot in 2009, this study seeks to identify the extent to which structural and procedural factors influenced the operation of Taiwan's disaster management system immediately after large-scale disaster events, and the extent to which Taiwan's disaster management system adopted new measures after the ChiChi Earthquake. There are four reasons why this study is justified in selecting these two cases for examination.

The first reason is that these two natural disasters were severe and caused significant loss of life and property. The ChiChi Earthquake was the most serious earthquake in the history of Taiwan, resulting in 2,405 deaths, more than 10 thousand people who lost their homes, thousands of public facilities and schools severely damaged, and over NT$ 356 billion (US$ 11.3 billion) in estimated losses (921 Earthquake Post-disaster Recover Commission [921EPRC] 2006). Typhoon Morakot was the deadliest typhoon to impact Taiwan in recorded history. In certain areas, the storm generated more than 2,700 mm (106.3 inch) of accumulated rainfall in 96 hours (Soil and Water Conservation Bureau, Council of Agriculture [SWCB] 2012). The rain triggered flooding and mudslides throughout southern Taiwan. Typhoon Morakot caused 675 deaths and missing people, and more than NT$ 16.4 billion (US$ 526 million) in agricultural losses (Council of Agriculture, Executive Yuan [COA] 2009). These disasters triggered nationwide response actions that involved a variety of organizations at multiple levels of jurisdiction.

The second reason is that these disasters generated damage that crossed counties and exceeded the response capacity of county and municipal level governments. Moreover, the central government became heavily involved in disaster response activities. An effective disaster response system, however, requires the coordinated and collective action of response organizations at all operational levels. These organizations formed a complex web of interactions, many of which were defined by jurisdictional boundaries or response activities.

The third reason is that the emergent response systems that evolved after the ChiChi Earthquake and Typhoon Morakot functioned as a nested set, and included organizational actors that operated at the national, county and municipal levels. In both events, the organizational actors can be described as the components and sub-components that composed the response systems that functioned with hierarchically defined authorities and responsibilities. By adopting the nested set perspective to examine organizational actors and their interaction patterns within and across components and sub-components, this research may generate findings that help to further understandings about the dynamics of interorganizational networks.

The final reason for the selection of these cases is that they present a unique opportunity for comparison. The formation of interorganizational networks may be influenced by certain structure and process factors, which may present themselves differently depending on the operational context. For example, Taiwan's "Disaster Prevention and Response Act" was created in 2000, shortly after the ChiChi Earthquake. The Act was revised several times between 2002 and 2009, and functioned as the national institutional structure for the disaster management system in Taiwan when Typhoon Morakot struck. The different institutional contexts that were present during these two disaster events may have led to the formation of different interorganizational network structures. More importantly, these differing institutional contexts

may have enabled the response networks to evolve at different rates. Identifying whether the Act facilitated or hindered the formation and evolution of the response network will help to direct the future disaster management policy in Taiwan.

3.3 RESEARCH QUESTIONS

Based upon the research problem and the literature reviewed in the previous chapters, this research examines the response networks that formed after the ChiChi Earthquake and Typhoon Morakot. These field studies were guided by following research questions.

1. **What were the initial conditions underlying the systems within which the response networks formed after the ChiChi Earthquake and Typhoon Morakot?**
    a. What were the most important features of the institutional environment within which the interorganizational response networks formed?
    b. What were the social and economic vulnerabilities of the impacted community?
    c. What was the political environment within which the interorganizational response network formed?

2. **To what extent did the response networks emerge and evolve after the ChiChi Earthquake and Typhoon Morakot?**
    a. To what extent did government agencies, private organizations, and nonprofit organizations form the system that responded to the events?
    b. To what extent did organizations interact across sectoral and jurisdictional boundaries?

c. To what extent did the systems develop and grow?

d. To what extent did the structure of the networks (density, diameter, and number of components) evolve?

3. To what extent did formal structure and process factors facilitate or constrain the formation of the response networks after the ChiChi Earthquake and Typhoon Morakot?

a. To what extent did formal structural factors facilitate or constrain the formation of the response networks?

b. To what extent did process factors facilitate or constrain the formation of the response networks?

4. To what extent did Taiwan's disaster response system exhibit indications of adaptation after the ChiChi Earthquake?

a. To what extent did the disaster response experiences in the ChiChi Earthquake influence the response activities in Typhoon Morakot?

b. To what extent were the structural factors of Taiwan's disaster response system strengthened or weakened with respect to the formation of functional disaster response networks?

c. To what extent were the process factors of Taiwan's disaster response system strengthened or weakened with respect to the formation of functional disaster response networks?

d. What were the factors that influenced the response system's capacity to learn?

3.4 SCOPE OF RESEARCH AND UNIT OF ANALYSIS

This research focuses on the emergency response activities that occurred during the three weeks that followed each disaster. The observation and investigation of the ChiChi Earthquake case is from September 21, 1999 to October 11, 1999. Although Typhoon Morakot made landfall in on August 7, 2009, this study will review documents published from August 5, 2009, the day the Central Weather Bureau of Taiwan issued a Sea Typhoon Alert for Morakot, to August 27, 2009.

The unit of analysis is the major entity that is chosen for analysis. This research's unit of analysis is the organizations that engaged in the disaster response networks that operated after the ChiChi Earthquake and Typhoon Morakot. This research will also map the changes in interorganizational interaction patterns among the organizations in the two studied cases. The organizational actor is selected as the major entity of analysis because this research aims to understand how the structure and process factors influenced the organizational decision making related to the development of interorganizational relationships during extreme events.

3.5 RESEARCH METHODS

To have a better understanding of the formation of interorganizational networks, this study employed multiple research methods (Golafshani 2003). Guided by the conceptual framework, data were collected through a documentation review, content analysis of newspaper articles, and semi-structured interviews. These sources were used to identify the initial conditions underlying the system at the time of each event, the evolution of the patterns of network structures, the processes and structures of interorganizational interactions, and the adaption and collaboration

activities that occurred in both disaster response systems. Table 2 presents the connection between research questions and research methods employed in this research.

Table 2 Connecting Research Questions and Research Methods

Research Questions	Research methods			Chapter
	Documentation Review*	Content Analysis (Newspaper: United Daily)	Semi-structured Interviews (42 interviews)	
What were the initial conditions underlying the systems within which the response networks formed during the two disaster events?	✓	✓		4
To what extent did the response networks emerge and evolve in the two disaster events?		✓		5
To what extent did structure and process factors facilitate or constrain the formation of the response networks in the two studied events?	✓		✓	6
To what extent did Taiwan's disaster response system exhibit indications of adaptation after the ChiChi Earthquake?	✓		✓	7

* Data sources include documents published by government agencies, academic institutes and scholars.

3.5.1 Documentation Review

This study reviewed and utilized documents published by government agencies, academic institutes and scholars. These documents include white papers, laws and regulations, special reports, statistical reports from Taiwanese government, research project reports, oral histories, and journal articles. These documents do not only provide information and knowledge about the institutional, social, and economic features of the two cases, they also supplement our understanding of organizational interactions after the disasters and the content of policy changes.

3.5.2 Content Analysis

This study conducted a content analysis of articles published in major Taiwanese newspapers to analyze the composition of the disaster response system, and the content and evolution of interorganizational interactions after the two disaster events. The collected data are used to identify the organizational actors involved in the response systems, and to analyze the content and the dynamics of the interactions among organizational actors. The coded dataset is utilized to generate statistical reports and social network analysis.

3.5.3 Semi-Structured Interviews

This research conducted semi-structured interviews with 42 informants from major organizations that were engaged in response activities after the two disaster events. Interviews are useful for collecting contextual information and for describing complex interactions that were not reported in newspapers (Marshall and Rossman 2006: 133). By directly talking with the decision makers that participated in the disaster response system, this research was able to validate the organization's decision making process, and the factors that influenced that process.

The interview questions focused on four areas of inquiry. First, I sought to identify the functions of the actors in the system and the challenges they faced when pursuing organizational goals. Second, I sought to identify the structural factors, including legal institutions, information and communication technology, and the organizational attributes, which influenced the formation of functional disaster response networks. Third, I asked questions to identify the process factors, such as the norms, communication and coordination process, and the social relationships among actors that influenced organizations' engagement in the interorganizational

response networks. Fourth, the interview questions identified the extent to which Taiwan's disaster response system changed and adapted after the ChiChi Earthquake.

3.6 DATA COLLECTION AND ANALYTICAL PROCESS

3.6.1 Data Collection and Data Coding

This research collected primary and secondary data from multiple sources. This section discusses the process used to conduct the content analysis and semi-structured interviews.

3.6.1.1 Conducting Content Analysis

This study collected data from newspaper articles to identify the organizations and interactions in the response systems. The data were collected from articles published in newspaper, *United Daily*, which is published in Taiwan. The articles collected to study the ChiChi Earthquake were published between September 21, 1999 and October 11, 1999. The articles collected to study Typhoon Morakot were published between August 5, 2009 and August 27, 2009. Each article used in this study was read in Chinese, and any organizations and transactions related to the two disaster events were coded into Excel spreadsheets. Table 3 shows the numbers of organizations and transactions coded for each studied disaster event. This study has identified 1,798 organizations and 3,169 transactions in the ChiChi Earthquake, and identified 978 organizations and 2,226 transactions in the Typhoon Morakot case.

Each identified organization and transaction was coded as a single entry. Each organization was then assigned a unique identification number and coded according to the

following variables: the *name* of the organization, the *date of entry* into the system, the *level of jurisdiction*, the *type* of organization, and the *source* where the organization was identified. Each identified transaction will be coded as an entry in the spreadsheet according to the following variables: the *date* the interaction occurred, the *initiator* and *recipient* of the interaction, the *purpose* of the interaction, and the *source* where the interaction was identified.

Table 3 Numbers of Identified Organizations and Transactions in the Response Systems of 1999 ChiChi Earthquake and 2009 Typhoon Morakot

	Range of Data Collection	Number of Organizations	Number of Transactions
ChiChi Earthquake	From September 21 1999 To October 11 1999	1,798	3,169
Typhoon Morakot	From August 5 2009 To August 27 2009	978	2,226

3.6.1.2 Conducting Semi-Structured Interviews

This study conducted semi-structured interviews with 42 individuals who worked in organizations that participated in the systems under analysis. These interviews were conducted in Taiwan between November 3, 2011 and January 10, 2012. The interview subjects were selected from the organizations identified in the system during the content analysis. The list of interviewed organizations, and the interview date and location is attached as Appendix A. I selected managers who had engaged in the organizational decision making process during the disaster response events. Each organization and other members in organizations potentially could contribute different perspectives to this research. However, with limited time and resources, efficiency and expertise played a role in the selection of subjects. To collect different viewpoints of diverse actors in the response system, I interviewed subjects from different sectors and jurisdictions.

Thus, this study employed a purposeful stratified sample strategy, which means the sample of interview subjects reflected the composition of the networks identified through the content analysis. A list of potential interview subjects was prepared based on the result of network analysis and documentary review. I reached subjects through several methods, including the help from personal contacts, snowballing, and direct contact with the organizations. The interview subjects were asked the series of semi-structured questions as identified in Appendix B. All interviews were conducted in Chinese (Mandarin) and were audio recorded. The recordings were transcribed in Chinese into a text document on the computer.

The distributions of interviewees are presented in Table 4. Thirty interviewees out of 42 were from the public organization at the national and county level, and the nonprofit organizations at the national level.

Table 4 Frequency Distribution of Interviewees who Participated in the 1999 ChiChi Earthquake and 2009 Typhoon Morakot Disaster Response Systems

Funding Source / Jurisdiction Level	**Public**		**Non-Profit**		**Private**		**Total**	
	N	%	N	%	N	%	**N**	**%**
National	10	23.8	10	23.8	4	9.5	24	57.1
County	9	21.4	4	9.5	0	0.0	13	31.0
Municipal	5	11.9	0	0.0	0	0.0	5	11.9
Total	24	57.1	14	33.3	4	9.5	42	100.0

Table 5 and Table 6 show the distribution of interviewees by each case. There were 19 informants interviewed for the ChiChi Earthquake case, and 30 informants for the Typhoon Morakot case. Since 7 of my informants had experienced both events, and they provided information on both cases during the interviews, the total number of interview conducted is 49.

Table 5 Frequency Distribution of Interview Samples for the 1999 Chichi Earthquake Case

Funding Source / Jurisdiction Level	Public		Non-Profit		Private		Total	
	N	%	N	%	N	%	**N**	**%**
National	3	15.8	5	26.3	1	5.3	9	47.4
County	5	26.3	2	10.5	0	0.0	7	36.8
Municipal	3	15.8	0	0.0	0	0.0	3	15.8
Total	11	57.9	7	36.8	1	5.3	19	100.0

Table 6 Frequency Distribution of Interview Samples for the 2009 Typhoon Morakot Case

Funding Source / Jurisdiction Level	Public		Non-Profit		Private		Total	
	N	%	N	%	N	%	**N**	**%**
National	8	26.7	8	26.7	3	10.0	19	63.3
County	5	16.7	4	13.3	0	0.0	9	30.0
Municipal	2	6.7	0	0.0	0	0.0	2	6.7
Total	15	50.0	12	40.0	3	10.0	30	100.0

3.6.2 Data Analysis

The data collected during the content analysis was utilized to generate descriptive and network analysis statistics. The transcripts of semi-structured interviews were also analyzed to answer the research questions. This section discusses the data analysis processes.

3.6.2.1 Descriptive Statistics

I analyzed the descriptive statistics for the organizations and interactions identified in the response systems. The data collected from the content analysis provide the information needed to answer the research question related to the number and type of organizational actors that

participated in disaster response activities after the ChiChi Earthquake and Typhoon Morakot. The descriptive statistics reveal the number, jurisdictional levels, source of funding, frequency distribution of the organizations, and the types of resources exchanged among organizations within the systems.

3.6.2.2 Network Analysis

Network analysis was used to identify the relationship patterns among the organizations that interacted within the disaster response system (Wasserman & Faust, 1994). I analyzed the organizational network of the response systems with the network analysis software *Ora*. Data collected from the content analysis was used to analyze the interactions among organizations that participated in the ChiChi Earthquake and Typhoon Morakot response systems. The network analysis results reveal the interaction patterns present within the systems. The network measures examined include density, fragmentation, distance, degree centrality, closeness centrality, and betweenness centrality (Wasserman & Faust, 1994). The results are used to identify the characteristics and the evolution of the response network in the two cases.

3.6.2.3 Analysis of Interview Transcripts

Once the audio recordings of the interviews were transcribed, I used the qualitative analysis software *MAXQDA* to code the substantive content of the interviews. The analysis was conducted by following the open coding process. First, I identified open codes by reviewing the transcripts line-by-line and identifying key words and phrases without presumptions in my mind. Second, I assigned a label for a cluster of words or phrases in which the informant presented an idea or a meaningful message. The open codes with similar labels were sorted into the same code bins. Third, the codes bins were fractured and restructured into axial codes. I extracted core

codes from axial codes based on my research purpose. A copy of the final codes used for the analysis is included in Appendix C.

3.7 THREATS OF VALIDITY AND RELIABILITY

The concept of validity and reliability is rooted in the positivism paradigm and are commonly addressed in the quantitative research. According to the positivist paradigm, the world is made up of objectively observable and measurable facts (Glesne and Peshkin 1992: cited by Golafshani 2003). Quantitative researchers attempt to construct an instrument in a standardized manner that can be used to measure the features of a subject. Issues of reliability and validity are examined to evaluate the quality of the research and ensure the generalizability of the results (Golafshani 2003). Validity determines whether the research truly measures that which it was intended to measure; and reliability refers to the idea of reliability or repeatability of results or observations (Golafshani 2003: 598-599). Although qualitative researchers hold a different perspective towards the objectivity of real world phenomena, there is still a need to check and examine the quality of research that employs qualitative methods (Maxwell, 1992).

This exploratory study seeks to understand the dynamics of interorganizational interactions in disaster response situations. I employed qualitative methods to identify the actors, the external environments, and the factors that influence the interactions among organizations and their adaptation to the changing environment. Even though this research does not aim to test hypotheses or to examine casual relationships among variables, there are issues related to validity and reliability that should be addressed. In this section, I discuss the construct validity, external and internal validity, and general reliability.

3.7.1 Construct Validity

In qualitative research, construct validity can be referred to as theoretical validity, which relates to the connection between the theories employed and the phenomena under study (Maxwell 1992). According to Joseph Maxwell, theories consist of two components: one is the concept that the theory employs, and another is the relationship among those concepts. When one associates these two components to the validity issue, theoretical validity has two aspects: "the validity of the blocks from which the researchers build a model, as these are applied to the setting or phenomenon being studied; and the validity of the way the blocks are put together, as a theory of these settings or phenomenon. (1992: 291)." The first aspect is construct validity and the second is internal validity. This section will address the construct validity and the first aspect of theoretical validity. Internal validity will be discussed in the following section.

I propose a conceptual framework that argues that the formation of interorganizational networks is a dynamic process interconnected with institutional structures. Questions about construct validity in this research relate to the extent to which the constructed conceptual framework is consistent with the formation of disaster response networks in the real world. This framework is composed of several concepts including: (1) the organizational actors; (2) the action situation they are facing; (3) the outcome that is derived from the actors' actions; (4) the pre-existing external environment; and (5) the factors that influence the actors' actions. This research aims to understand the relationship among these concepts, which explain how the external environment, structural and process factors influence the organizational actors' ability to solve the problems they faced, and how the outcomes generated from the actions also influenced the environmental attributes and factors.

The validity of the framework construct is supported by the scholarly research and literature addressed in chapter two. The conceptual framework of this research is a synthesis of the literatures on network governance, complex adaptive system theory, institutional analysis, decision making, and policy change (Koppenjan and Klijn 2004; Kooiman 2003; Axelrod and Cohen 2000; Birkland 1997, 2006; Comfort 1999, 2007; Kettl 1993; Klein 1993; Ostrom 1999, 2005; Simon 1996, 1997). The formation of interorganizational networks in disaster response situations is a collective action event that occurs in a social system in which actors interact with each other to achieve common goals (Comfort 1999; Comfort and Wukich 2007; Comfort 2007). There are scholars that have adopted the network perspective to examine the disaster response activities (Kapucu 2005; Drabek 1981; Moynihan 2005; Tierney and Trainor 2003; Wukich 2011; Haase 2009), and confirmed the adaptability of disaster response systems (Birkland 2006).

3.7.2 Internal Validity

Internal validity refers to the extent to which research measurements can accurately capture the relationship among concepts that this research intends to explore. This research employed a content analysis on articles published in newspapers to extract the structure of the interorganizational networks that formed after the studied disaster events, and conducted semi-structured interviews with key informants to learn the organizational decision making process of engaging collective actions, the factors that influenced the process, and the extent to which adaptation and learning occurred in the disaster response system. There are potential threats of internal validity related to the research methods employed in this research.

First, there is a concern about the accuracy of network data reported in the newspapers. This research collected network data from the content of newspaper articles. The concern is

whether the interorganizational network that is constructed from the data reported in newspapers is the same as the real world network structure. Considering that newspapers are a form of mass media, and the limitations of resources and space, it is impossible for newspapers to report all of interactions that occurred in the studied response systems. The information was filtered and selected by journalist and editors before the readers read the printed articles. Newspapers with certain positions and ideologies may report information that favors certain individuals, groups or organizations. For example, to serve the target readers, the focus and content of news in national and local editions are usually different.

However, there are studies that argue that social network research does not need to focus on the preciseness of particular interactions. Rather, the true structure of the network, that is, the relatively stable patterns of interaction, is more important (Romney and Faust 1982; Freeman and Romney 1987; Hammer 1985, cited by Wasserman and Faust 1994: 57). Even though the newspaper did not reveal all the interactions that occurred in the disaster response system, the collected network data still obtains a certain degree of internal validity in representing the structure of true networks. This research collected all the organizational activities that were reported in the newspaper in the national and local editions, and also collected the information from all pages including politics, business, social, and entertainment. With the full set of interactions, this research obtained network data that cover the reported interactions at the national and local levels, and also include the activities of both public and non-public organizations.

The second threat to internal validity comes from bias related to the selection of the interview informants. Due to resource and time limitations, this study did not interview all the organizations within the response system. There were situations in which initial interview

informants were not available. The concerns of selection bias were moderated by identifying alternative subjects with similar operational backgrounds, thereby ensuring that this research obtained the perspectives of subjects from different jurisdiction levels and different funding sources. Another selection bias is caused by the fact that fewer subjects were selected from the ChiChi Earthquake case. At the time of this study, it had been more than ten years since the ChiChi Earthquake. Accordingly, it is difficult to find key informants who were actually engaged in the response activities after that disaster event. This research uses the oral history conducted by scholars in Taiwan's Academia Sinica, and the governmental publications on the ChiChi Earthquake events as supplementary materials to support my analysis.

The third threat to internal validity comes from the accuracy of the informant's responses during the interviews. The informants' responses might contain personal bias and errors in memory, especially for the ChiChi Earthquake case, which happened more than a decade before the interviews. Therefore, during interviews, even though I tended to be a listener, when there were opinions that conflicted with the documents or previous interviewees' responses, I would ask the interviewees to elaborate the arguments to clarify the discrepancies. Therefore, the triangulation among different sources of information moderated the threats of internal validity.

3.7.3 External Validity

There are also concerns about external validity, which refers to the transferability of the research findings to the target population of the study and the universe of other populations. The findings generated by this study may not be transferable to other disaster events. This is because history does not repeat itself, and every disaster is unique in terms of the cause, type, impacts, location and timing. Therefore, the network structures and the interactions among organizations in other

events may be different from those studied in this research. Furthermore, the research results may not be transferable to disaster management systems in other countries. Taiwan's disaster management system adopts the single-hazard approach design, which is different from countries that adopt the all-hazard approach. Differences in institutional and cultural contexts may lead to different network formation processes and different patterns of network structures.

3.7.4 Reliability

Reliability refers to the extent to which the results of a study can be reproduced. A common issue about measuring the pattern of networks relates to the dynamics of network structures. The relationships among social actors could evolve and change over time. Therefore, even with the same instrument, measuring the network structure of the same community at different periods of time may generate different results. This research avoided the issue by collecting the network data from the newspaper on each day for the three weeks after the disaster events. However, since this study only collected the network data from one newspaper, there remains a threat to the reliability of this study. Data collected from different newspapers may generate different patterns of network structures for the two events.

There is also a potential threat to reliability that is caused by the semi-structured interviews. The interviews were conducted in Mandarin, and to minimize interpretation errors, the interviews were recorded and transcribed in Chinese. As a native Chinese speaker, I have no problem understanding and interpreting the response of the interviewees. However, the translation could be a potential treat of reliability. Translating one language to another language is an interpretation process (Marshall and Rossman 2006: 111-113). The use of vocabulary and

grammatical structure is associated with the individual's perception and cultural background. There might be Chinese words that are difficult to translate precisely into English.

4.0 DISASTER RESPONSE SYSTEM IN TAIWAN

This research investigates the formation of interorganizational networks after two disaster events in Taiwan, the ChiChi Earthquake in 1999 and Typhoon Morakot in 2009. This chapter answers the following research question: what were the initial conditions underlying the systems within which the response networks formed after the ChiChi Earthquake and Typhoon Morakot? The chapter also addresses three sub-questions. First, what were the most important features of the institutional environment within which the interorganizational response networks formed? Second, what were the social and economic vulnerabilities of the impacted community? Third, what was the political environment within which the interorganizational response network formed? The analysis that is conducted in this chapter reviews the institutional structure, social and economic vulnerability of the impacted region, the impacts of the disaster events, and the response activities that were taken by the public and non-public organizations for the cases under analysis. As shown in the conceptual framework proposed by this research, disaster emergency responders operated in a dynamic system that changes and adapts to the operational environment.

4.1 THE INITIAL CONDITIONS OF THE 1999 CHICHI EARTHQUAKE

Located at the intersection of Eurasian Plate and Philippine Sea Plate, on the Pacific Ring of Fire, Taiwan is highly susceptible to seismic damage. According to historical records, there were

more than 50 earthquakes above magnitude 6 detected in Taiwan during the 20th century (Central Weather Bureau 2012). However, Taiwan did not possess nationwide disaster management plans or regulations until the National Emergency Plan was issued in January 1994. It was the Northridge Earthquake, which occurred in California in 1994, which alerted the Taiwanese government about the need to develop a nationwide disaster management system (Lee 2007).

In the same year, while the government was discussing the plan, an aircraft owned by China Airlines crashed near Nagoya, Japan in April 1994. The Taiwanese government observed the efficient and prompt response actions taken by the Japanese government. The Taiwanese government also decided that they would refer to the Japanese disaster management system and include man-made disasters in their national emergency plan. In August 1994, the Executive Yuan, the highest administrative authority in Taiwan, issued the National Emergency Plan, which was the legal basis for disaster management activities when the ChiChi Earthquake occurred in 1999.

This section describes the institutional design of Taiwan's disaster management system, and the social, economic, and political features of the regions impacted by the ChiChi Earthquake, the consequences of the earthquake, and the major actions that were taken by the actors in the disaster response system.

4.1.1 Institutional Design of the Disaster Management System in 1999

Taiwan's National Emergency Plan framed the roles of government agencies at national, county and municipal levels when the ChiChi Earthquake occurred in 1999. The National Emergency Plan was not a legislative law, but rather, it was an administrative plan that was issued by

Executive Yuan. Therefore, the plan only presented the logic of the policy structure within the administrative system, and had limited legal effect.

The Plan addressed three disaster management areas: prevention, response and recovery. The Plan also listed the specific disaster prevention and preparation tasks, and assigned those tasks to different ministries according to the nature of their functions. The tasks listed in the Plan included: promoting disaster prevention knowledge to the public, providing appropriate equipment and facilities for potential disaster threats, identifying the high risk areas and establishing control over the areas through limited use and zoning regulations, and conducting scientific research and investigation to acquire essential knowledge about disaster risks. To carry out these tasks, each jurisdiction of government was required to develop disaster prevention and response plans, and the ministries were required to develop and implement the disaster operations plan for the assigned tasks. Each jurisdiction was also required to hold an annual meeting to review, approve, and monitor the implementation of the operational plans. The Prime Minister hosted the meetings, and the ministers of each department were required to attend. The plan also required government ministries to conduct disaster research and draft related regulations and laws.

For disaster response situations, the plan required each jurisdiction to establish an emergency response center after the occurrence of an emergency. The ministries and administrative agencies related to the emergency situation would then form emergency response task forces that would support decision making within the emergency response center and the execution of disaster response tasks. The disaster response tasks included: search and rescue, situation information collecting and reporting, evacuation, building inspection, sanity and health

care, and the management of dead bodies. Figure 2 shows the design of Taiwan's disaster management system as it existed in 1999.

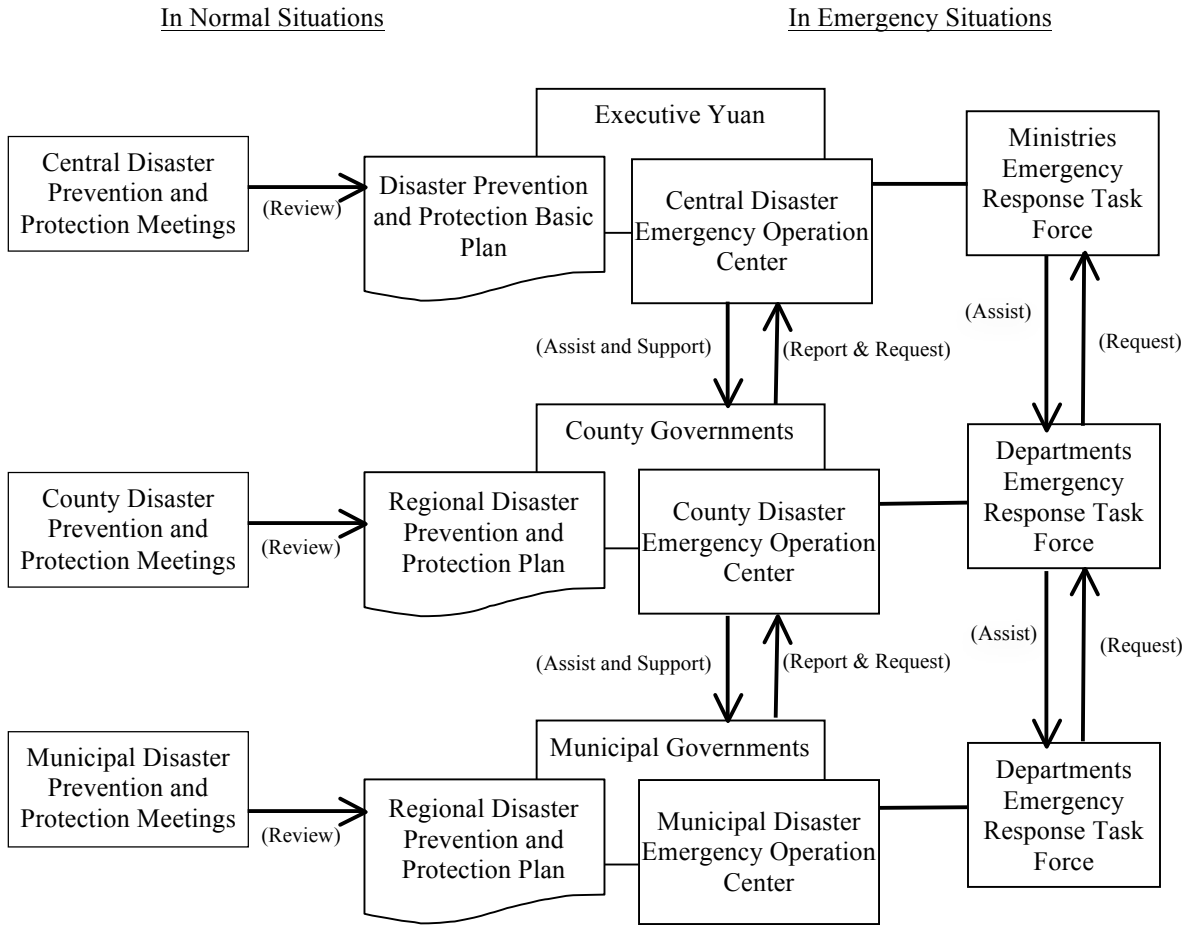


Figure 2 Organizational Design of Taiwan's Disaster Management System in 1999

4.1.2 Vulnerability of Region

Geologists have identified 33 active faults throughout Taiwan, which have been formed by seismic activity (Central Geological Survey Institute 2010). The Chelungpu Fault runs across both Taichung County and Nantou County. The movement of the fault during earthquakes can generate severe above ground damage. Nantou County is the one of the most vulnerable regions

along the fault. Nantou County is located at the geographical heart of Taiwan, and is the only county that does not border the coast. It covers an area of 410 km^2 and had a population of 545,874 in 1998. Its population density was 133 people/km^2, which is far lower than the national average population density of 616 people/km^2 (Department of Household Registration 2011).

The county is composed of one city, four towns, and eight villages. Eighty-five percent of Nantou County is made up of mountains and hills. These geographic features have limited the development of Nantou County. First, most mountains and forests are protected as nature reserves, where economic development activities are regulated by the national government. With limited income from agricultural and tourist industries, Nantou is one of the poorest counties in Taiwan, and it relies heavily on financial support from the central government (Zhao and Liu 2007). Second, the mountainous geography makes travel to and within Nantou County difficult. Towns and villages are also scattered and isolated, and roads were the dominant mode of transportation. There were also no major railroads, airports, ports, or highways that directly connected Nantou County to the rest of the country. It was also difficult to build a major commercial hub within Nantou that could connect all of the towns and villages (Fu 2000).

Taiwan is a highly centralized country in which most of the local governments, except Taipei City, the capital city, rely on grants from the central government. With tight budgets, disaster management tasks were not a policy priority. The disaster prevention and response capacity of the local governments were limited by the lack of investment in personnel, training, and equipment. Fire departments were responsible for disaster response tasks. However, most of fire departments did not possess the equipment needed for disaster response tasks. The fire fighters only received firefighting training. To appropriately carry out the disaster management activities, local officials needed capacity building, training, and equipment.

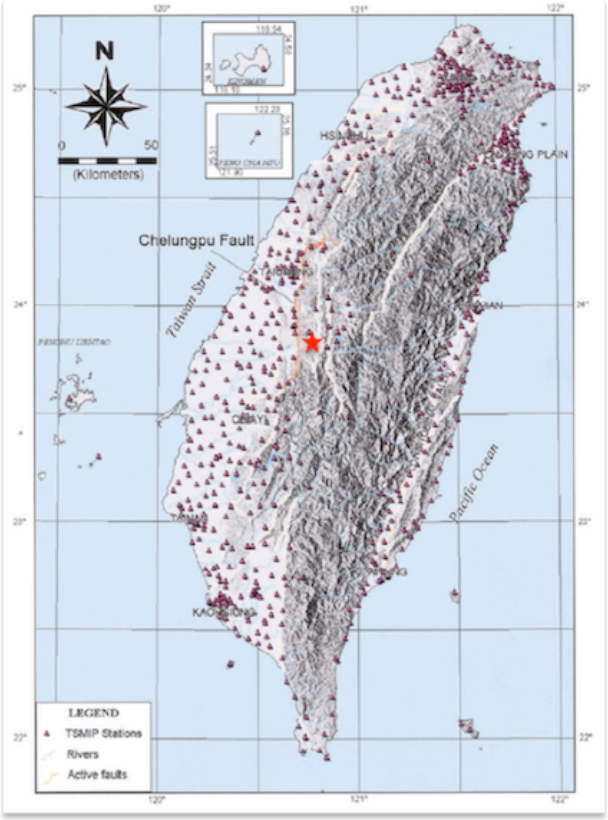
Although the disaster prevention and response tasks were added to the government agencies at all levels, the number of personnel who worked within these agencies had not been increased. Moreover, governmental agencies did not hire any additional personnel to execute the new disaster management tasks. All the disaster management related works continued to be implemented under historical personnel levels, which undermined the overall disaster response capacity of the system.

Because of the risk of earthquakes, the central government also established a national standard building code. Many of the buildings located in central Taiwan were low or mid-rise buildings, which were built with reinforced concrete frame, brick infill walls, and typically accommodated commercial uses on the first floor, with residences above. The brick infill is often discontinued on the street side to provide open commercial areas and covered pedestrian walkways on the ground level. This building structure, and the use of non-ductile concrete frames, created weak first stories, and made the buildings fragile to earthquakes (Dong et al. 2000). Since 1982, concrete building standards in Taiwan have included ductile steel reinforcement requirements to eliminate non-ductile failures. However, while the building code was strict, code implementation in Taiwan had been weak (Wu and Lindell 2004). Therefore, the buildings in central Taiwan, the high-risk region, were highly vulnerable to earthquakes.

4.1.3 Impacts of the 1999 ChiChi Earthquake

The ChiChi Earthquake occurred at 1:47 am on September 21, 1999 and registered as a magnitude 7.6 earthquake. The epicenter was located at ChiChi, Nantou County, and 8 kilometers underground. Aftershocks followed the main shock, and 9 out of 250 aftershocks registered higher than 6 on the Richter Scale. The rupture of the Chelungpu Fault extended 85

kilometers. In some areas, the faulting caused additional upward ground deformations of 6 to 7 meters. Figure 3 shows the location of Chelungpu Fault and the epicenter of Chichi Earthquake.



Source: Shin and Teng (2001: 896)

Figure 3 Map of Taiwan Showing Chelungpu Fault and the Epicenter

The power of the earthquake and the fault movement caused significant damage in several counties, especially in Nantou and Taichung Counties, which were located on the Chelungpu Fault and close to the epicenter. The earthquake caused high numbers of deaths and substantial property losses. For example, the event caused 2,405 deaths, 10,718 injuries, and more than 44,338 households reported damage (Ministry of Interior 1999). Table 7 presents an overview of the number of lives lost and the amount of household damage by county.

Table 7 Distribution of Deaths, Injuries and Household Damage by County: 1999 ChiChi Earthquake

County	Deaths	Injuries	House Completely Damaged (Household)	House Half-Damaged (Household)
Taipei Municipality	71	316	76	325
Keelung City	-	-	1	3
Hsinchu City	2	4	5	-
Taichung City	113	1,112	1,484	4,953
Chiayi City	-	11	24	-
Taipei County	39	145	230	3,264
Taoyuan County	3	84	1	2
Hsinchu County	-	4	5	13
Miaoli County	6	196	529	473
Nantou County	889	2,421	23,127	16,792
Taichung County	1,170	5,602	-	-
Changhua County	29	387	-	-
Yunlin County	80	423	916	321
Chiayi County	2	5	30	91
Tainan County	1	1	1	1
Ilan County	-	7	-	-
Total	2,405	10,718	44,338	41,633

Source: Ministry of Interior 1999

The earthquake also caused heavy damage to lifeline systems and transportation infrastructure, which made disaster response activities even more difficult. The earthquake ruptured lifeline systems, including water and sewer systems, electrical power systems, natural gas and liquid fuel systems, and telecommunication systems. Most of the damage to water, sewage, and natural gas systems was a result of the damage inflicted upon buildings and roads. The strong ground motion also caused damage to high-voltage transmission lines and power towers, the critical link between the power-deficient northern part of the island and surplus supplies in the south. The damage directly caused power outages throughout the island, and indirectly led to the disruption of telecommunication and cellular phone systems, and transportation systems. The ground deformation and the landslides damaged roads, highways and bridges throughout Taichung, Nantou, Chiayi and Yunlin Counties. The railroads on the west coast were also disrupted. Many villages were inaccessible due to the damage inflicted upon

transportation systems, and emergency access was often limited to helicopters and walking (Dong et al. 2000).

Table 8 Summary of Estimated Financial Losses by Category: 1999 ChiChi Earthquake

Item	NT$ Billion	US$ Billion
1. Asset Loss (Direct Loss)	2,597.1	8.2
1.1. Buildings & Equipment	2,426.8	7.6
1.1.1. General Housing, Residential Units	1,140.2	3.6
1.1.2. Durable Goods of Households	244.4	0.8
1.1.3. Government Agencies	119.0	0.4
1.1.4. Industry and Commercial Services	174.7	0.5
1.1.5. Electrical Hydrological, Gas and Fuel Facilities	120.3	0.4
1.1.6. School Buildings	390.4	1.2
1.1.7. Medical, Clinical Facilities	138.9	0.4
1.1.8. Agricultural Facilities	70.1	0.2
1.1.9. Military Installations	28.8	0.1
1.2. Transportation Infrastructure	170.2	0.5
2. Loss of Potential Revenues (Indirect Loss)	971.2	3.1
2.1. Agriculture	23.6	0.1
2.2. Industry	729.6	2.3
2.2.1. Manufacturing	691.2	2.2
2.2.2. Electricity, Gas and Water	38.4	0.1
3. Services	218.0	0.7
Sum of Nominal Financial Losses	**3,568.3**	**11.2**

Source: Directorate General of Budget, Accounting and Statistics, cited by Shaw 2000
Exchange Rate: NT$ 31.8 to US$ 1.

According to a report by the Directorate General of Budget, Accounting and Statistics, the overall economic losses caused by the earthquake was an estimated US$11.5 billion, including direct and indirect asset losses (Table 8). The US$8.4 billion direct asset losses included buildings, equipment and transportation infrastructure damages. The US$3.1 billion in indirect losses came primarily from the interruption of manufacturing industries due to the two-week power outage. The total financial losses amounted to 3.5% of Taiwan's GDP in 1999 (Shaw 2000).

4.1.4 Responses to the 1999 ChiChi Earthquake

This section states the responses activities taken by the public and nonpublic actors in the Taiwanese disaster management system.

4.1.4.1 Governmental Response

Right after the earthquake, the National Fire Agency established the Central Disaster Emergency Operation Center (CDEOC) as designed in the Plan. Prime Minister Shaw arrived at the CDEOC at 3 a.m. and announced nine emergency response measures. After he held discussions with several high-level government officials, Prime Minister Shaw decided to establish the Incident Command Post at Nantou County (Lin et al. 2000: 871). President Lee also held a high-level meeting on September 21 to learn about the situation. To unify the command system and to coordinate resources, President Lee established the 921 Earthquake Response Center at the second high-level meeting on September 22, and appointed Vice-President Liang as the chief commander of the response center. The 921 Earthquake Response Center was established in Nantou County. Vice President Liang then issued a series of disaster response policies. For example, the Center arranged to have each ministry of the central government adopt a severely impacted town or village and to provide direct assistance to that town or village (Lin et al. 2000: 865).

Due to the extensive damage that exceeded the response capacity of the administrative system, President Lee declared a state of emergency on September 25. The issuance of emergency decrees allowed the administrative system to take the measures necessary to provide immediate relief to the victims, to obtain special financial resources, and to streamline administrative procedures. During a high-level meeting that occurred on September 26, President

Lee asked Executive Yuan to establish a post-disaster recovery commission to carry out the necessary measures for recovery. The 921 Earthquake Post-Disaster Recovery Commission was established the next day, September 27, and the Vice Prime Minister was appointed as the Chief Executive Director of the Commission (p. 978).

The military also played a critical role in disaster response activities. The Ministry of Defense deployed the army and established six command posts in the impacted areas immediately after the earthquake. The military also formed ten medical teams to provide emergency medical services, distributed food and water, and deployed the soldiers to repair roads and bridges (p. 872).

The most critical actions, in terms of saving lives, were taken at the municipal level. Local governments played the key role of rescuing people after the earthquake. They were also critical in terms of collecting and reporting situations and implementing the relief policies made by the government at higher levels of jurisdiction. However, most local governments did not have the preparation, training, or equipment needed to undertake those actions. The collapse of township buildings in the severely impacted area also weakened the response capacity of the municipal governments (921EPRC 2006:47). With limited equipment, personnel, and insufficient information, the managers of towns and villages could not effectively coordinate town-wide collective action through formal administrative authority. Rather, they responded to the situation by utilizing resources from their personal networks or the resources that were convenient to access in the community (Comfort 2000; Kuo 2001).

The performance of county governments varied, depending on the scale of damage and administrative capacity. Taipei City and Taipei County, for example, had relatively minor impacts and both governments possessed sufficient capacities and resources to carry out response

activities through the administrative system. However, due to the severity of the damage, and the lack of administrative resources, the Nantou County and Taichung County governments failed to perform their response functions as an organized system (921EPRC 2006: 46). More importantly, a series of measures that had been taken by the central government worked to weaken the role of the county governments. First, the issuance of emergency decrees and the establishment of the 921 Earthquake Post-Disaster Recovery Commission allowed the central government to obtain more resources than were needed for the disaster response and recovery tasks. The disaster response and relief policies made by the central government also directly affected the allocation of resources at the municipal level. Second, the direct assistance and support of the military and ministries allowed the officials and politicians at the municipal level to communicate with the decision makers in the central government without going through county governments (p. 43).

4.1.4.2 Engagement of Non-Governmental Actors

The earthquake also aroused vigorous engagement from the non-governmental sector. Various nonprofit organizations, including international and domestic search and rescue groups, religious groups, grassroots groups, social welfare services organizations, and universities engaged in the disaster response networks. Table 9 shows the composition of the organizational actors engaged in the response system during the first three weeks after the earthquake. The result of content analysis of the newspaper articles, these data indicate that nonprofit organizations made up 40% of the response system, 35% of the actors were governmental organizations, and the remaining 25% were organizations from the private sector.

Table 9 Frequency Distribution: Actors that Responded to the 1999 ChiChi Earthquake by Jurisdiction and Source of Funding

Funding Source / Jurisdiction Level	Public		Non-Profit		Private		Total	
	N	%	N	%	N	%	**N**	**%**
International	30	1.7	28	1.6	18	1.0	76	4.2
National	174	9.7	215	12.0	244	13.6	633	35.2
County	249	13.8	283	15.7	159	8.8	691	38.4
Municipal	184	10.2	183	10.2	31	1.7	398	22.1
Total	637	35.4	709	39.4	452	25.1	1798	100.0

Source: Results of content analysis conducted on the newspaper articles published in the *United Daily* between September 21,1999 and October 11, 1999

Search and rescue teams and humanitarian relief groups from 20 countries arrived in Taiwan and provided professional assistance during the first week after the earthquake (Lin et al. 2000: 883). Domestic religious groups such as the Tzuchi Foundation, I-Guang Doh, and Christian churches, promptly mobilized resources to assist people who had lost their homes. For example, the Tzuchi Foundation, the major Buddhist organization in Taiwan, arrived at the remote and mountain areas and provided food and shelters to the victims before the government's supplies were delivered (921EPRC 2006: 51). There was also a large number of citizens' and grassroots groups that voluntarily participated in disaster relief services, or donated money and supplies to the victims. According to statistics provided by Taiwan's Ministry of Interior, the amount of money raised by the public and non-public organizations for the ChiChi Earthquake event totaled NT$33.8 billion, or US$ 1.1 billion. However, due to the insufficient information about demand, and lack of coordination, the donated supplies were ineffectively distributed and generated high organizational costs.

4.1.5 Changes Made after the 1999 ChiChi Earthquake

The ChiChi Earthquake was a critical test to the capacity of Taiwan's disaster response system. It revealed the discrepancies between the existing policy and its performance in practice. The experience of the ChiChi Earthquake indicates that Taiwan needed to establish a disaster management system throughout the entire administrative system, at all jurisdictional levels. However, as an administrative ordinance, the National Emergency Plan did not provide policy makers with the authority to promote systematic change. Instead, Taiwan needed to pass a legislative law that would clearly identify the responsibilities and obligations of governmental and non-governmental entities within the disaster management system.

While the National Emergency Plan was issued in 1994, the Ministry of Interior had also been working on a Disaster Prevention and Protection Act, the legislative law for disaster management. Due to the difficulties related to reaching a consensus on substantive content, the Act stayed in the legislative process for more than five years. The ChiChi Earthquake of 1999 was the trigger that promoted the lawmaking process for the Act. After intensive discussion, the Disaster Prevention and Protection Act was passed by Congress on June 30, 2000, and activated on July 19, 2000.

4.2 THE INITIAL CONDITIONS OF THE 2009 TYPHOON MORAKOT

The ChiChi Earthquake experience triggered the Taiwanese government to pass the Disaster Prevention and Protection Act in 2000, the legal basis to guild disaster management policy and operations in Taiwan. The Taiwanese disaster management system experienced several

transportation and public safety incidents and natural disasters after the passage of the Act. However, none of them challenged the system like Typhoon Morakot. Thus, Typhoon Morakot tested the capacity of the Taiwanese emergency response system and revealed its weaknesses.

This section describes the features of Disaster Prevention and Protection Act under which the Taiwanese emergency response system operated during the first three weeks after Typhoon Morakot. This section also analyzes the vulnerability of the impacted regions, the consequences of Typhoon Morakot for Taiwan's society, and the actions taken by the actors in the response system. Finally, this section identifies the structural and operational changes that were made to Taiwan's disaster management system after Typhoon Morakot.

4.2.1 Institutional Design of the Disaster Management System in 2009

The Disaster Prevention and Protection Act of 2000 is the legal basis for the operation of Taiwan's disaster management system. The Act also provides guidelines for disaster management organizations, disaster planning, disaster prevention and preparation, emergency response and recovery tasks, and the sanctions that stem from violations related to the Act. The Disaster Prevention and Protection Act confirmed the single-hazard design of the Taiwanese disaster management system. The Act specifically lists the types of disasters and identifies the responsible ministries in the central government for each types of disaster. These ministries are responsible for developing disaster prevention policies and plans, and monitoring and coordinating the implementation of those policies and plans at the county and municipal levels. Table 10 shows the ministries and assigned types of disasters.

Table 10 Summary: Types of Disasters and Responsible Agencies Identified in the Disaster Prevention and Protection Act of 2000

Responsible Agencies	Types of Disasters
Ministry of Interior	Windstorm, earthquake, fire, explosion
Ministry of Economic Affairs	Flooding, draught, public gas, fuel pipeline and power transmission line failure, mining disasters
Council of Agriculture, Executive Yuan	Frost, debris flow, forest fire
Ministry of Transportation and Communications	Air crash, shipwreck and land traffic accidents
Environmental Protection Agency	Toxic Chemical Materials

Source: The Disaster Prevention and Protection Act of 2000

The tasks and responsibilities of disaster management are distributed across three jurisdiction levels: national, county (city), and municipal. Figure 4 shows the structure of the disaster management system that was in effect during 2009. Similar to the National Emergency Plan, the Act requires governments at all levels to hold annual meetings, develop disaster management plans, and implement disaster management policies based on the developed plans. When there is an emergency situation that meets certain criteria, governments are required to establish Emergency Operation Centers. The ministries of the central government, or the departments of the local governments related to the emergency situation, would then be responsible for organizing the emergency response task forces that would assist the decision making of the emergency operations center.

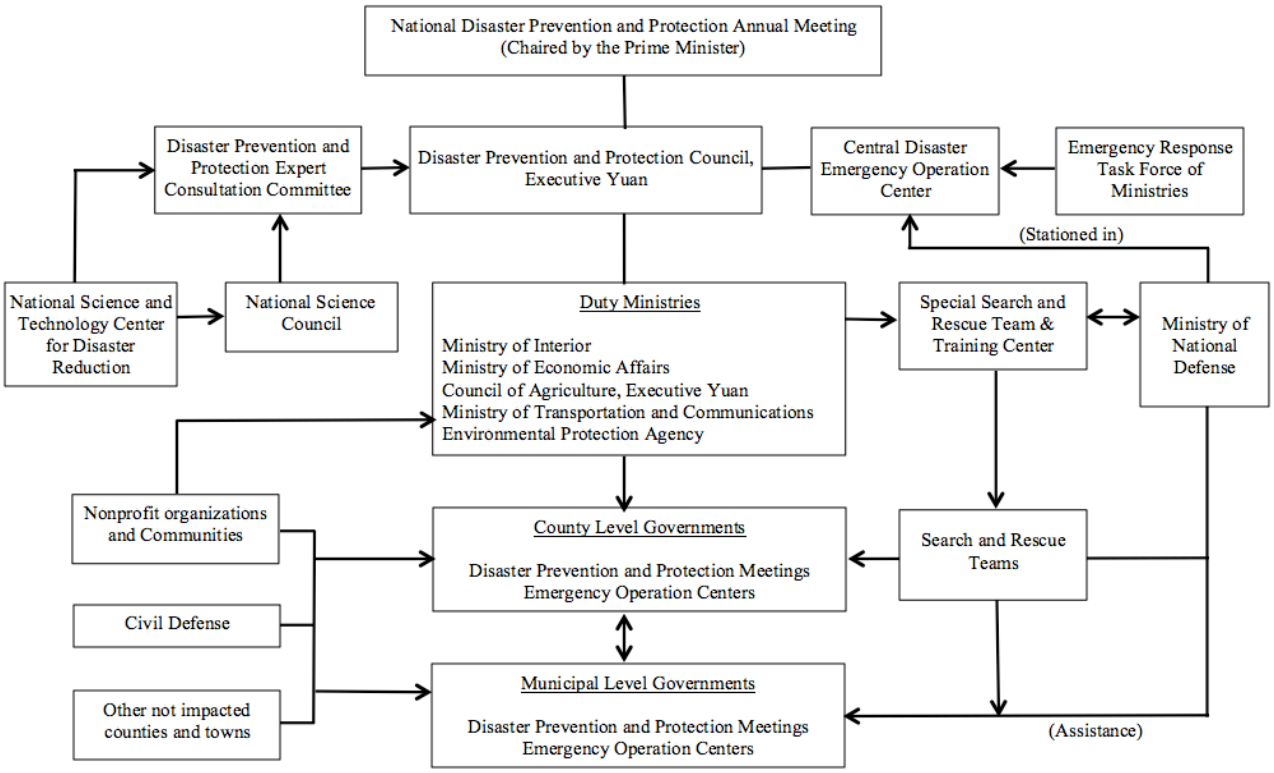


Figure 4 Organizational Design of Taiwan's Disaster Management System in 2009

To coordinate and implement disaster management policies across ministries in the central government, the Act required the Executive Yuan to establish the Disaster Prevention and Protection Council. The Disaster Prevention and Protection Council is responsible for the development of disaster management plans, and the review and implementation of disaster management policies across the ministries. The importance of disaster expertise and the development of a disaster management knowledge base were also recognized in the system. The Act indicated that the Disaster Prevention and Protection Council could establish a Disaster Management Expert Consultative Committee and a National Science and Technology Center for Disaster Reduction.

The organizational response to the ChiChi Earthquake revealed many problems in Taiwan's disaster response system, including a lack of professional search and rescue personnel

and equipment. Therefore, the Act required the National Fire Agency, located within Ministry of Interior, to establish Special Search and Rescue Squads and a Search and Rescue Training Center for building an essential emergency response capacity. The county governments were also required to build search and rescue teams. The Act lists the tasks and responsibilities of government at each jurisdiction level during the emergency response situations, such as evacuation, search and rescue, shelter, relief assistance, medical care, repair the damaged infrastructures, archival activities, and the hosting of international disaster assistance groups. The governments could also take special measures that would impact individual and property rights, but only to achieve the public interest during the emergency. The role of military, civil defense, voluntary organizations and communities are also included in the Act.

4.2.2 Vulnerability of Region

Located on the path of storms that form on the Western Pacific, Taiwan confronts the threats generated by typhoons on an annual basis. These storms bring strong winds and rainfalls to Taiwan during the summer. The tremendous rainfall generated by these storms usually causes flooding and landslides throughout various regions of Taiwan. Interestingly, given that the ground motion generated by the ChiChi Earthquake loosened the soil in the mountain area, these regions have become highly sensitive to rainfall.

Due to the history of governmental policies and economic development, the high-risk areas that are threatened by typhoons are also where the indigenous people of Taiwan live. At the end of 2008, there were approximately 500,000 indigenous people in Taiwan, 52% of whom live in the mountain areas. In counties such as Nantou, Pingtung, Hsinchu, Chiayi, Ilan and

Kaohsiung County, 80 to 95 percent of indigenous peoples live in the mountain areas (Department of Housdhold Registration 2011).

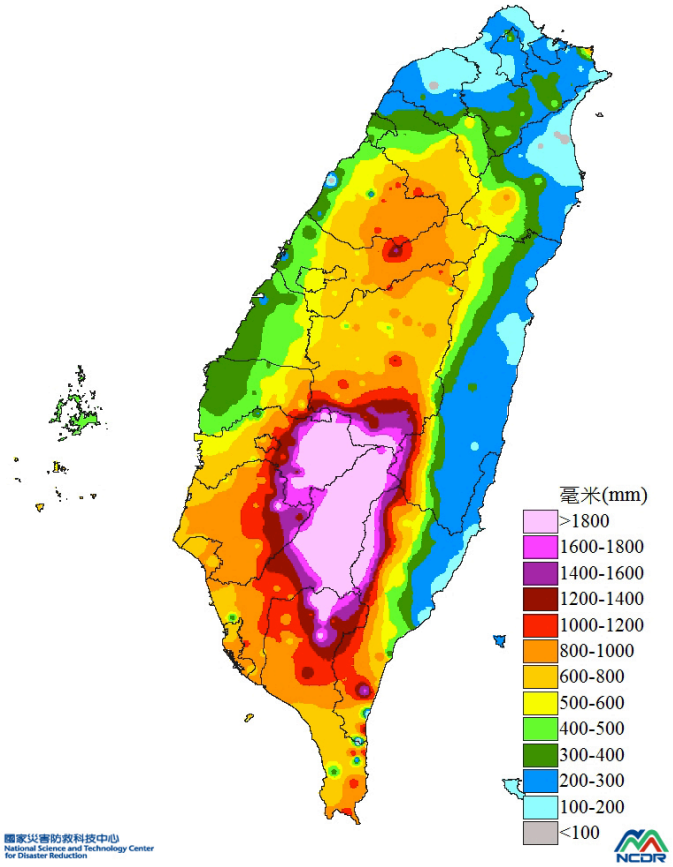
Indigenous people are considered a minority in Taiwanese society, and they possess lower social and economic status than the Han ethnic group. There is also a cultural barrier that separates the Han group from the indigenous groups. Even though the indigenous groups have adapted their life style in response to the influences from the Han, those who live in remote and mountain areas still maintain elements of their traditional lifestyles. Their major economic activities rely heavily on natural resources such as hunting, fishing and farming. Indigenous people also maintain a close relationship with nature and the land, and they are also closely connected with a tribal form of organization. Since the Han community is the group that governs Taiwan, disaster management policies rarely took needs of indigenous people into consideration.

Even though the Disaster Prevention and Protection Act reinforced the role of municipal governments in the disaster management system, municipal governments remained the weak link in the Taiwanese disaster management system. The lack of sufficient personnel to plan and execute disaster management policies remained a problem for governments at the municipal level. For example, the towns and villages in rural areas usually cover wide geographic areas; however, they tend to only have one staff member, who works part-time, on disaster management activities.

4.2.3 Impacts of the 2009 Typhoon Morakot

In early August 2009, Taiwan was facing a drought and was expecting a typhoon that had formed on the Philippine Sea to bring much needed rainfall. The Central Weather Bureau of Taiwan issued a Sea Typhoon Alert on August 5th for an approaching storm that had been named

Typhoon Morakot. The typhoon made landfall on August 7th, just before midnight, with winds peaking at 150 km/h. This was the equivalent of a Category 1 hurricane on the Saffir-Simpson Hurricane Scale (Central Weather Bureau 2009; The Disaster Management Expert Consultation Committee 2010). The storm moved slowly and brought tremendous rainfall. When it left Taiwan at 2 pm on August 8th, Pingtung County in the Southern Taiwan was reporting extensive flooding.



Source: National Science and Technology Center for Disaster Reduction, 2009

Figure 5 Accumulated Rainfall between August 5 to August 10, 2009

Although the typhoon had left, the rain continued to fall until August 10th. Some areas recorded accumulated rainfall that exceeded 1,800 mm (Figure 5). While the annual average accumulated rainfall in Taiwan is 2,500 mm, Typhoon Morakot brought accumulated rainfall

that exceeded 80% of the annual level in only 96 hours. This intensive rainfall triggered compound disasters, which included floods, landslides, and debris flows in southern Taiwan. Situation reports issued by the National Disaster Emergency Operation Center indicated that at least 600 people were dead or missing throughout southern Taiwan (Table 11). Most were residents of Xiaolin village in Jiaxian Township of Kaohsiung County. The village was buried by a massive landslide that destroyed most of the town (The Disaster Management Expert Consultation Committee 2010).

Table 11 Frequency Distribution: Deaths, Missing, and House Damage Caused by 2009 Typhoon Morakot

	Kaohsiung County	Pingtung County	Other Counties	Total
Deaths and Missing	565 (81%)	48 (7%)	62 (12%)	675
Houses Damaged (Households)	866 (54%)	278 (18%)	456 (28%)	1600
Sheltered (Individuals)	2732 (61%)	1427 (31%)	341 (8%)	4500

Source: The Disaster Management Expert Consultation Committee 2010: 17

The rainfall caused damage to lifeline systems, transportation infrastructure, and generated significant agriculture costs. The rainfall in the mountain areas brought large amounts of soil and dirt to surge into rivers and artificial lakes. The strong river currents destroyed bridges, roads and dikes. Soil and dirt blocked the water and sewage systems, and the floods damage electrical and telecommunication facilities. Table 12 shows the Typhoon's impact to lifeline systems, telecommunication and transportation infrastructures.

Taiwan's agricultural sector suffered losses of about NT$16.4 billion (US$ 526 million) in Typhoon Morakot, according to the Taiwan Council of Agriculture (Executive Yuan 2009). The total losses included crops, livestock, poultry, aquatic and forest produce worth NT$ 10.8

billion, with NT$ 5.6 billion of the losses located in Pingtung, Chiayi, Taitung, and Kaohsiung counties (Table 13).

Table 12 Summary: Damage of Lifeline Systems, Telecommunication and Transportation Infrastructure

Types		Impacts (Units)
Lifeline Systems	Water	730,972 (Household)
	Electricity	1,595,419 (Household)
	Natural Gas	626 (Household)
Telecommunication	Telephone	114,990 (Landlines)
	Cellphone	3,343 (Stations)
Transportation	Highways and Roads	364 (spots)

Source: Ministry of Economic Affairs and National Communication Council; cited by Central Disaster Emergency Operation Center 2009

Table 13 Estimated Losses in Agriculture after 2009 Typhoon Morakot

	NT$ (billion)	US$ (million)
1. Loss in Agriculture Produce	10.8	348.4
1.1. Crops	4.9	158.1
1.2. Livestock and Poultry	1.5	48.4
1.3. Aquatic	4.2	135.5
1.4. Forests	0.2	6.4
2. Loss in Agriculture facilities	5.6	180.6
2.1. Farming land	4.8	154.8
2.2. Farming facilities	0.2	6.5
2.3. Livestock facilities	0.1	3.2
2.4. Aquatic facilities	0.5	16.1
Total Loss in Agriculture	**16.4**	**526.0**

Source: Taiwan Council of Agriculture, Executive Yuan; cited by Central Disaster Emergency Operation Center 2009

4.2.4 Responses to the 2009 Typhoon Morakot

4.2.4.1 Governmental Response

After the Central Weather Bureau of Taiwan issued a Sea Typhoon Alert on August 5th, the Central Disaster Emergency Operation Center (CDEOC) was activated and informed the ministries and agencies to station themselves in the CDEOC, exactly as the Disaster Prevention and Protection Act prescribed. The Council of Agriculture, the agency responsible for the management of landslides and debris flows, formed the emergency task force on August 5th to monitor the situation. The task force was composed of scholars and experts from universities, National Science and Technology Center for Disaster Reduction, and the Central Disaster Emergency Operation Center. They integrated the weather data from the Central Weather Bureau, the dataset of high-risk rivers, the debris flow warning issuance standards, and historical landslides and debris flow disaster events and made the decision to evacuate residents in high-risk areas. Between August 6 and August 11, the Council of Agriculture had issued 21 warnings, and identified 519 high-risk rivers in Nantou, Yunlin, Chiayi, Tainan, Kaohsiung and Pingtung Counties (Central Disaster Emergency Operation Center 2009).

However, as the rainfall continued and damage emerged in southern Taiwan, the CDEOC received criticisms that it was falling to coordinate activities and to provide timely emergency rescue and relief assistance. While the digital mass media repeatedly played images of flooding, broken bridges, collapsed buildings, the CDEOC did not possess the information it needed to make effective decisions about the allocation of personnel and resources. According to the design of Taiwan's disaster response system, the central government coordinates resources and provides assistance upon requests from local governments. Under circumstances where local governments fail to provide sufficient information, the central government should still be able to

collect information through multiple advanced technology, communicate with local agencies via satellite phones, use remote sensing satellite to collect images, or detect the situation with helicopters (Disaster Management Expert Consultation Committee 2010). Regrettably, these technologies did not function after the Typhoon because heavy clouds blocked the satellite signals, and it was dangerous for helicopters to operate under the weather conditions. In addition, due to the lack of practice and maintenance, satellite phones did not play a role during the response to Typhoon Morakot. Therefore, several villages in the remote and mountain areas remained isolated due to the breakdown of lifeline, transportation and communication systems.

The county governments that were expected to execute the emergency response measures also faced difficulties in their response to a compound disaster that exceeded their capacity. The 119 emergency phone systems were overloaded and did not function due to the number of incoming calls related to information submissions or requests. The county governments, such as Pingtung County, did not have sufficient personnel and equipment to rescue citizens that were trapped by the flood. The Pingtung County government also applied for assistance from the military. However, this assistance was delayed due to the long, formal application and communication processes.

County governments were also responsible for providing relief assistance to the victims. Due to the number of affected people, the county governments did not have sufficient personnel stationed in shelters to provide the necessary services. The county governments with good coordination and management capacity, such as Kaohsiung County government, managed to mobilize local nonprofit organizations to help with shelter activities (Control Yuan 2009).

The municipal governments were responsible for evacuating people who lived in the impacted areas and reporting the disaster situation to higher-level authorities. However, both the

municipal governments and the local people failed to recognize the risk and did not leave after receiving the evacuation order from the central and county governments. Even though Taiwan has, on average, 5 typhoon threats a year, Typhoon Morakot was an extreme case that brought a historically high volume of rainfall, which exceeded the people's knowledge and experience. When the central government issued the order to evacuate the residents, some people made judgments based on their previous experience and refused to evacuate. The officials at the municipal level also failed to recognize and effectively communicate the severity of risks to the residents (Disaster Management Expert Consultation Committee 2010).

4.2.4.2 Engagement of Non-Governmental Actors

Similar to the response network for the ChiChi Earthquake, various types of nongovernmental organizations, including international humanitarian assistance groups, domestic search and rescue teams, religious groups, grassroots groups, human service organizations, and private companies from different jurisdiction levels engaged in the disaster response network for Typhoon Morakot. Table 14 shows the composition of the organizational actors identified in the response system during the first three weeks after the typhoon.

The Ministry of Foreign Affairs of Taiwan rejected assistance from other countries during the first few days, due to its misjudgment of the situation. Later, the Taiwanese government adjusted its decision and began to receive assistance from foreign countries. For example, the Department of Defense of the United States provided cargo planes and helicopters that conducted a total of 55 missions, delivering 20 pieces of excavation equipment and relief supplies to affected areas (U.S. Agency for International Development 2009).

Table 14 Frequency Distribution: Actors that Responded to 2009 Typhoon Morakot by Jurisdiction and Source of Funding

Funding Source / Jurisdiction Level	Public		Non-Profit		Private		Total	
	N	%	N	%	N	%	**N**	**%**
International	16	1.6	14	1.4	5	0.5	35	3.6
National	110	11.2	117	12.0	147	15.0	374	38.2
County	109	11.1	135	13.8	35	3.6	279	28.5
Municipal	154	15.7	128	13.1	8	0.8	290	29.7
Total	389	39.8	394	40.3	195	19.9	978	100.0

Source: Results of content analysis conducted on the newspaper articles published in the *United Daily* between August 5, 2009 and August 27, 2009

Nongovernmental organizations such as voluntary search and rescue teams, Taiwan Red Cross, World Vision Taiwan, religious groups, and social welfare services organizations also actively engaged in response activities. Some of the nonprofit search and rescue teams even arrived at the remote and isolated villages before governmental agencies. Since there were a large number of nonprofit organizations that tried to engage in disaster response, relief and recovery services, the Taiwan Red Cross formed the Alliance of 88 Flood Relief Services to coordinate the resources and efforts among nonprofit organizations. The Alliance also collaborated with the government to provide services.

While most of the private companies engaged in disaster response activities by donating money and supplies, some private companies were heavily involved and cooperated with the governmental and nonprofit organizations. For example, the Carrefour Company in Taiwan worked closely with the Taiwan Red Cross and the Ministry of Interior, and utilized their strength in logistical planning and facilities management to deliver relief supplies to the impacted areas.

The public was also actively engaged in social media activities after Typhoon Morakot. As the impact of the disaster became a focusing event that drew the public's attention, people sought to acquire information about the situation. Since the government did not effectively respond to all requests for assistance, and the emergency phone system was broken, people turned to the internet to share and exchange information. Users on social media sites such as Facebook, Twitter, Plurk, and the Black Board System, shared and discussed the disaster situation, asked for assistance, and coordinated voluntary groups that visited the impacted areas. Even though these sites collected and exchanged information that complemented the official emergency reporting system, rumors and out of date information were wide spread in the cyber community, which led to miscommunications between the government and the public.

4.2.5 Changes Made after the 2009 Typhoon Morakot

After Typhoon Morakot, Taiwan's government recognized that it needed to revise the Disaster Prevention and Protection Act to improve its disaster management system to minimize the consequence of future disasters. In August 2010, the Legislative Yuan amended the Act in the following ways. First, the name of National Fire Agency was changed to the "National Disaster Prevention and Protection Agency." By changing the name of the agency, Taiwan's government reinforced the Agency's role in implementation of disaster management policy. Second, the Executive Yuan established the Disaster Prevention and Protection Office to implement the policies made by the Disaster Prevention and Protection Council. The Office operates with several full time staff. The Director of the Office is staffed by the Deputy Director General of the National Disaster Prevention and Protection Agency, Ministry of Interior.

Third, county and municipal governments are now required to establish Disaster Prevention and Protection Offices for the implementation of disaster management policies. While county and municipal governments have gradually established these Offices, they continued to be operated as task forces, which means they have yet to hire new full time staff to operate these Offices.

Fourth, the military is now empowered to engage actively in disaster response activities, and does not need to wait for a request from the administrative system. Disaster response is now formally listed as one of the military's responsibilities. The Ministry of Defense also needs to invest in the equipment and training that is needed to build its capacity to respond to disasters.

5.0 ANALYSIS OF THE NETWORK STRUCTURE OF TAIWAN'S DISASTER RESPONSE SYSTEM

This chapter investigates the characteristics of these two response systems by analyzing the composition of the networks and the structures created by the interactions that took place immediately after the two disaster events. I analyze the composition of the networks, interactions patterns among organizational actors, and the evolution the network structures of these systems. The data presented in this section reflects the growth and evolution of the disaster response networks as they were reported in the newspaper, not as they actually operated in the real world. The analysis presented in this chapter is based on the results of the content analysis conducted on articles published in the United Daily during two separate periods of time: September 21, 1999 through October 11, 1999 and August 5, 2009 through August 27, 2009.

5.1 IDENTIFYING THE CORE SYSTEM

After the disaster events occurred, organizational actors from the public, nonprofit and private sectors began to react in various ways. This study sorted all reported organizational activities into sixteen categories. Table 15 shows the result of analysis of the frequency of each type of activity. The results indicate that a significant portion of the actors present in the response systems donated money or raised funds. In fact, 30% of the total number of transactions in the

ChiChi response system and 23% of the total number of transactions in the Morakot response system involved such activities. However, this high frequency of Donation/Fundraising transactions may skew the results of the analysis, as some of these organizations did not directly engage in the response system, but rather, only made one-time donations. This study excluded such non-critical organizations from the datasets to address the threat of skewed data. The following section explains the criteria and process used to identify the non-critical organizations in the Donating/Fundraising category, and analyzes the composition and the distributions of transactions of the core systems, which do not contain the excluded organizations.

Table 15 Frequency and Type of Transactions in the Response Systems: 1999 ChiChi Earthquake and 2009 Typhoon Morakot

Rank	ChiChi Earthquake			Typhoon Morakot		
	Types of Transactions	**Frequency**	**%**	**Types of Transactions**	**Frequency**	**%**
1	Donating/Fundraising	950	30.0	Donating/Fundraising	511	23.0
2	Damage/Need Assessment	394	12.4	Emergency Response	286	12.8
3	Recovery	267	8.4	Damage/Need Assessment	244	11.0
4	Disaster Relief	259	8.2	Disaster Relief	229	10.3
5	Emergency Response	195	6.2	Reconstruction	200	9.0
6	Communication	191	6.0	Service Interruption	140	6.3
7	Reconstruction	166	5.2	Communication	131	5.9
8	Service Interruption	145	4.6	Government Aids/Service/Policies	108	4.9
9	Medical Care/Health	142	4.5	Recovery	98	4.4
10	Government Aids/Services/Policies	113	3.6	Political Activities	73	3.3
11	Mitigation	104	3.3	Medical Care/Health	69	3.1
12	Legal/Enforcement/Fraud	83	2.6	Preparation	44	2.0
13	Political Activities	51	1.6	Legal/Enforcement/Fraud	38	1.7
14	Earthquake Assessment/Research	38	1.2	Others	28	1.3
15	Religious Ceremony	37	1.2	Weather Monitor/Report	17	0.8
16	Others	34	1.1	Religious Ceremony	10	0.4
	Total	3,169	100.0	**Total**	2,226	100.0

5.1.1 Organizations Removed from the System

This study excluded organizations that fit the following two criteria: (1) it was only involved in the "Donating/Fundraising" transaction, and (2) it was only reported in the newspaper once. Based on these criteria, the data cleaning process followed three steps. In step one, I identified the organizations that only engaged in the "Donating/Fundraising" transaction. In step two, I sorted these organizations by their frequency of mention in the system and identified the organizations that were only reported once. In step three, I excluded the organizations that only appeared in the system once, as well as their related transaction record, from the dataset. This process allowed me to reduce the frequency of the Donating/Fundraising category in each response system, while keeping this type of transactions in the analysis. The characteristics of the excluded data from the two systems are analyzed in the following subsections.

5.1.1.1 1999 ChiChi Earthquake Response System

In the ChiChi Earthquake response system, 890 of the 1,792 identified organizations engaged in donation and fundraising related activities. Table 16 indicates that these 890 organizations were distributed among national, county and municipal levels. When categorized according to their source of funding, almost 50% or 93 of those organizations were classified as nonprofit. When compared to the full system (Table 9 in Chapter 4), the excluded data has a higher percentage of organizations engaged in donating or fundraising activities classified as nonprofit or municipal.

Table 16 **Frequency Distribution of Organizations Engaged in Donating/Fundraising by Jurisdiction and Source of Funding: 1999 ChiChi Earthquake**

Funding Source / Jurisdiction Level	Public		Non-profit		Private		Total	
	N	%	N	%	N	%	**N**	**%**
International	11	1.2	18	2.0	15	1.7	44	4.9
National	51	5.7	93	10.4	143	16.1	287	32.2
County	58	6.5	171	19.2	48	5.4	277	31.1
Municipal	113	12.7	161	18.1	8	0.9	282	31.7
Total	51	26.2	93	49.8	143	24.0	890	100.0

There were also 630 organizations in this transaction category that met the criterion of being reported only once. The distribution of the organizations that were removed is different than the distribution of the organizations in the full system. Table 17 indicates that, of the 630 excluded organizations, 375 or 59.5% of the organizations were from the nonprofit sector, and 306 or 48.6% of these nonprofit organizations were classified as county or municipal levels.

Table 17 **Frequency Distribution of Excluded Organizations by Jurisdiction and Source of Funding: 1999 ChiChi Earthquake**

Funding Source / Jurisdiction Level	Public		Non-Profit		Private		Total	
	N	%	N	%	N	%	**N**	**%**
International	10	1.6	17	2.7	15	2.4	42	6.7
National	21	3.3	52	8.3	100	15.9	173	27.5
County	14	2.2	153	24.3	46	7.3	213	33.8
Municipal	47	7.5	153	24.3	2	0.3	202	32.1
Total	92	14.6	375	59.5	163	25.9	630	100.0

5.1.1.2 2009 Typhoon Morakot Response System

In the Morakot response system, 425 of the 970 organizations identified in the full system engaged in donation and fundraising activities. Table 18 shows that, similar to the distribution of the ChiChi response system, almost 50% were nonprofit organizations. In terms of jurisdiction levels, 174 or 40.9% of the organizations were classified as national, 106 or 24.9% were county, 114 or 26.8% were municipal, and 31 or 7.3% were international.

Table 18 Frequency Distribution of Organizations Engaged in Donating/Fundraising by Jurisdiction and Source of Funding: 2009 Typhoon Morakot

Funding Source / Jurisdiction Level	Public		Non-Profit		Private		Total	
	N	%	N	%	N	%	**N**	**%**
International	13	3.1	13	3.1	5	1.2	31	7.3
National	20	4.7	55	12.9	99	23.3	174	40.9
County	31	7.3	52	12.2	23	5.4	106	24.9
Municipal	20	4.7	86	20.2	8	1.9	114	26.8
Total	51	19.8	93	48.5	143	31.8	425	100.0

Of the 425 organizations in this transaction category, 285 or 67% met the criterion of being reported only once in the Morakot system. The distribution of excluded organizations is different than the distribution of the organizations in the full system and in the Donation/Fundraising category. As Table 19 indicates, of the 285 excluded organizations, 159 or 55.8% were nonprofit organizations, and 82 or 28.8% of the nonprofit organizations were identified as municipal. Also, 73 or 25.6% of the excluded organizations were identified as private organizations from the national level.

Table 19 Frequency Distribution of Excluded Organizations by Jurisdiction and Source of Funding: 2009 Typhoon Morakot

Funding Source / Jurisdiction Level	Public		Non-Profit		Private		Total	
	N	%	N	%	N	%	**N**	**%**
International	9	3.2	9	3.2	5	1.8	23	8.1
National	3	1.1	23	8.1	73	25.6	99	34.7
County	2	0.7	45	15.8	21	7.4	68	23.9
Municipal	5	1.8	82	28.8	8	2.8	95	33.3
Total	19	6.7	159	55.8	107	37.5	285	100.0

5.1.2 Composition of the Core Systems

After the non-critical organizations and related interactions were excluded from the full system dataset, the remaining organizations were used to construct the core response system. This section analyzes the composition of the core system for the two studied events by source of funding and jurisdiction level. This section also maps the network diagram of the response systems and identifies the organizations that occupied the central positions in the networks according to degree centrality and betweenness centrality.

5.1.2.1 Organizational Actors in the 1999 ChiChi Earthquake Response System

After the non-critical organizations and interactions were excluded from the full system dataset, 1,162 distinct organizations remained. These organizations formed the core response system. When sorted by their source of funding and jurisdiction level, as shown in Table 20 the system was composed of 544 or 46.8% public organizations, 332 or 28.6% nonprofit organizations, and 286 or 24.6% private organizations. In terms of their level of jurisdiction, there were 458 or

39.5% organizations classified as national, 474 or 40.8% classified as county, 196 or 16.9% classified as municipal, and 34 or 2.9% came from foreign countries.

Table 20 Frequency Distribution of Organizations in the Core System by Jurisdiction and Source of Funding: 1999 ChiChi Earthquake

Funding Source / Jurisdiction Level	Public		Non-Profit		Private		Total	
	N	%	N	%	N	%	**N**	**%**
International	20	1.7	11	0.9	3	0.3	34	2.9
National	152	13.1	162	13.9	144	12.4	458	39.4
County	235	20.2	129	11.1	110	9.5	474	40.8
Municipal	137	11.8	30	2.6	29	2.5	196	16.9
Total	544	46.8	332	28.6	286	24.6	1162	100.0

Figure 6 presents the network map that visualizes the composition and the structure of the reported ChiChi response network with isolates and pendant nodes hidden. This network map shows that the key actors located at the center of the response network were mainly from the public sector. The organizations classified as nonprofit and private tended to be located off the center of the network. Some nonprofit organizations did not connect with the major response network, but rather, they worked within their own closed group.

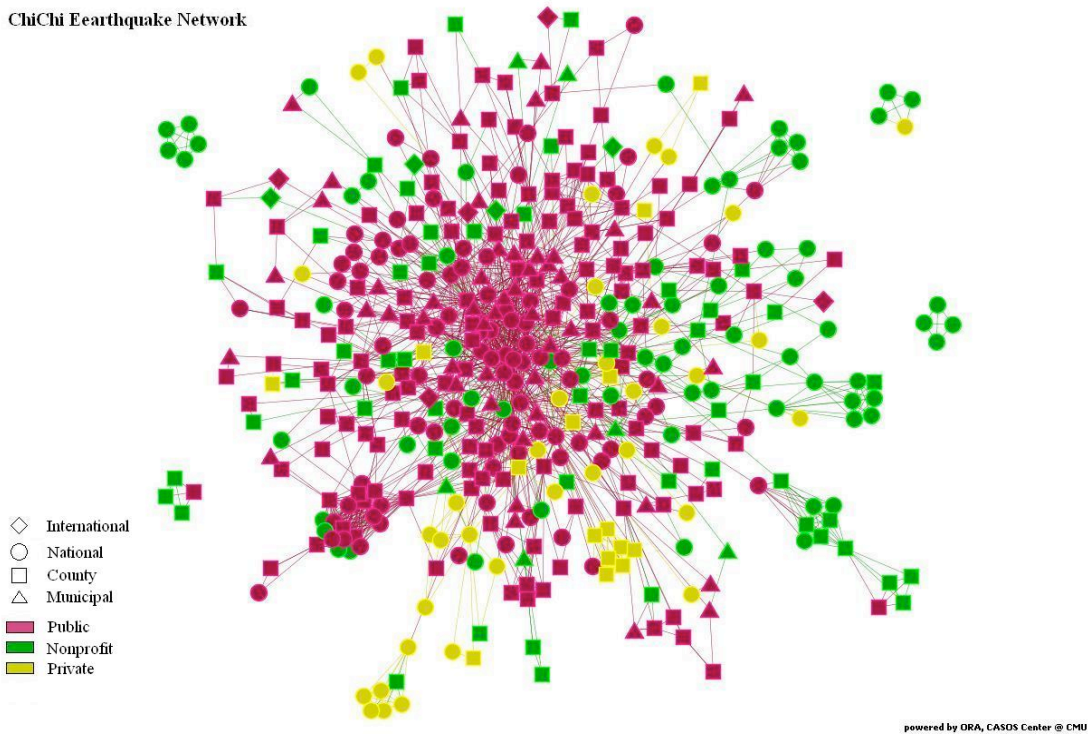


Figure 6 Network Map of the 1999 ChiChi Earthquake Response System

The measures of centrality identify the organizational actors located in the center of the network. This study identified the key actors using two measures of centrality: degree centrality and betweenness centrality. Degree centrality is the measure that evaluates actors in the network by the number of ties that actors possess (Wasserman and Faust 1994: 178). In this analysis, degree centrality refers to the number of interactions that a given organizations exchanged with other organizations. The top ten organizations ranked with highest degree of centralization are listed in Table 21. The results show that all ten organizations were from the public sector, six of which were classified as national, and the rest were classified as county.

Table 21 Rank Order of Key Organizations by Degree Centrality: 1999 ChiChi Earthquake

Rank	Name	Source of Funding	Jurisdiction Level
1	Ministry of National Defense	Public	National
2	Nantou County Government	Public	County
3	Taichung County Government	Public	County
4	Executive Yuan of Taiwan	Public	National
5	Ministry of Interior, Executive Yuan	Public	National
6	Ministry of Education, Executive Yuan	Public	National
7	Ministry of Economic Affairs, Executive Yuan	Public	National
8	921 Earthquake Post Disaster Recovery Commission, Executive Yuan	Public	National
9	Taichung City Government	Public	County
10	Taiwan Power Company	Public	National

Betweenness centrality, the second way to measure the position of organizational actors in a response system, focuses on whether a particular actor can control interactions between pairs of other actors in the network (Wasserman and Faust 1994: 188). The organizations that possess an intermediary or gateway position can access resources and information and are considered to be central to the network. In this analysis, betweenness centrality means the extent to which a given organization is located between other organizations. Table 22 lists the top ten organizations with the highest betweenness centrality in the ChiChi response system. The table shows that public organizations possessed central positions in the network, with the Ministry of National Defense ranked as the organization with the highest betweenness centrality.

Table 22 Rank Order of Key Organizations by Betweenness Centrality: 1999 ChiChi Earthquake

Rank	Name	Source of Funding	Jurisdiction Level
1	Ministry of National Defense	Public	National
2	Ministry of Education, Executive Yuan	Public	National
3	Executive Yuan of Taiwan	Public	National
4	Nantou County Government	Public	County
5	Public Health Bureau, Keelung City Government	Public	County
6	Taichung County Government	Public	County
7	Ministry of Interior, Executive Yuan	Public	National
8	Taiwan Power Company	Public	National
9	Ministry of Economic Affairs, Executive Yuan	Public	National
10	Miaoli County Government	Public	County

5.1.2.2 Organizational Actors in the 2009 Typhoon Morakot Response System

After the non-critical organizations and interactions were removed from the full system dataset, 685 distinct organizations remained, which means that the response system formed after Typhoon Morakot was smaller than the ChiChi response system. Table 23 indicates that, in the Morakot response system, 52.8% or 362 of the organizations were classified as public, 34.3% or 235 organizations were nonprofit, and 12.8% or 88 organizations were private. In terms of their jurisdictional level, only 12 or 1.8% of the identified organizations were from foreign countries. The system was composed by 39.6% or 271 organizations classified as national, 207 organizations, or 30.2%, classified as county, and the remaining 195 organizations, or 28.5%, were classified as municipal. Compared to the ChiChi system, a low percentage of organizations were classified as private.

Table 23 Frequency Distribution of Organizations in the Core System by Jurisdiction and Source of Funding: 2009 Typhoon Morakot

Funding Source / Jurisdiction Level	Public		Non-Profit		Private		Total	
	N	%	N	%	N	%	**N**	**%**
International	7	1.0	5	0.7	0	0.0	12	1.8
National	103	15.0	94	13.7	74	10.8	271	39.6
County	103	15.0	90	13.1	14	2.0	207	30.2
Municipal	149	21.8	46	6.7	0	0.0	195	28.5
Total	362	52.8	235	34.3	88	12.8	685	100.0

Figure 7 presents a network map that visualizes the composition and structure of the reported response network that formed after Typhoon Morakot. This map is similar to the ChiChi response system in that the actors located at the center of the network were public. The map also shows that, when compared to the ChiChi system, there were fewer nonprofit and private organizations connected to the core network structure.

Table 24 lists the top ten organizations that have the highest degree centralization scores. Similar to the findings from the ChiChi system, all ten organizations were from the public sector. In terms of jurisdiction level, there were six organizations classified as national and the four remaining were classified as county.

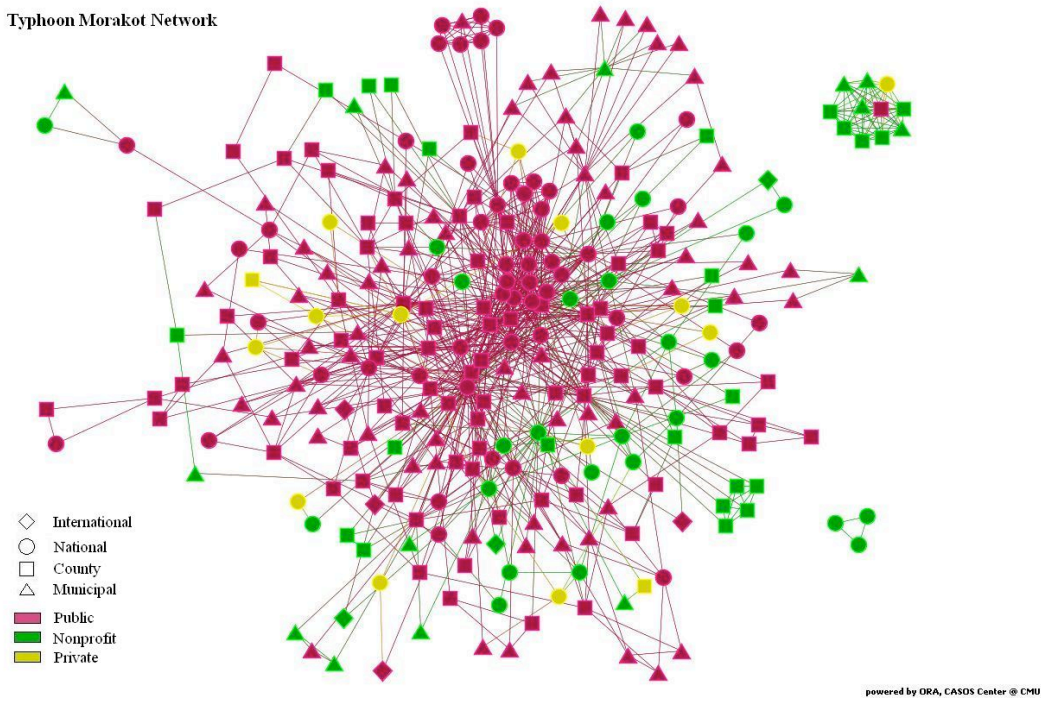


Figure 7 Network Map of the 2009 Typhoon Morakot Response System

Table 24 Rank Order of Key Organizations by Degree Centrality: 2009 Typhoon Morakot

Rank	Name	Source of Funding	Jurisdiction Level
1	Ministry of National Defense	Public	National
2	Tainan County Government	Public	County
3	Executive Yuan of Taiwan	Public	National
4	Kaohsiung County Government	Public	County
5	Chiayi County Government	Public	County
6	Pingtung County Government	Public	County
7	President of Taiwan	Public	National
8	Ministry of Education, Executive Yuan	Public	National
9	Ministry of Interior, Executive Yuan	Public	National
10	Ministry of Transportation and Communication, Executive Yuan	Public	National

Table 25 lists the top ten organizations with the highest betweenness centralization scores. All ten organizations were from the public sector. However, in terms of jurisdictional

level, there were more county level organizations located at the center of the system. Six out of the ten organizations were classified as county, and the other four were classified as national. This finding suggests that the county government played a more significant role as an intermediary or gateway among other organizations in the Morakot response system.

Table 25 Rank Order of Key Organizations by Betweenness Centrality: 2009 Typhoon Morakot

Rank	Name	Source of Funding	Jurisdiction Level
1	Tainan County Government	Public	County
2	Ministry of National Defense	Public	National
3	Kaohsiung County Government	Public	County
4	Ministry of Education, Executive Yuan	Public	National
5	Chiayi County Government	Public	County
6	Pingtung County Government	Public	County
7	Taitung County Government	Public	County
8	Ministry of Interior, Executive Yuan	Public	National
9	River Management Office, Water Resources Agency, Ministry of Economic Affairs	Public	County
10	President of Taiwan	Public	National

5.1.3 Transactions

In the two disaster response systems under analysis, the participating organizations performed various activities. This study sorted all identified transactions into 16 categories and analyzed the actors that performed these transactions by source of funding and jurisdictional level.

5.1.3.1 1999 ChiChi Earthquake Response System

Table 26 presents the matrix of the 2,601 transactions that were performed following the ChiChi Earthquake. The largest proportion, 15.1% or 394 of the transactions involved damage and need assessment activities. The earthquake damaged the transportation infrastructures, lifeline systems, and buildings. Thus, damage and needs assessment was a critical step for decision

makers who needed to obtain this information in order to allocate resources for disaster response and relief measures. The results of the building inspections and damage assessments played a large role in the decisions made to grant victims financial assistance from the government. Most damage and need assessment activities were performed by public sector actors that operated at the county level.

The second largest proportion, 14.8% or 385 of the transactions involved donation and fundraising activities. Even though this study excluded part of the data that initially fell in this category, it was still one of the most frequently observed activities in the system. This indicates that, after the earthquake, a significant amount of money and supplies was delivered to the response system. Disaster recovery and relief followed a close third and fourth, with 10.2% or 265 and 10.0% or 259 of the transactions. When the characteristics of the actors involved in the total transactions were analyzed, 64.9% of the actors were public, 20.0% were nonprofit, and the remaining 15.1% were private.

Table 26 Frequency Distribution of Transactions by Jurisdiction and Source of Funding: 1999 ChiChi Earthquake

Type of Transactions	# of Transactions		# of Actors by Funding Source						# of Actors by Jurisdiction Level								Total Number of Actors	
			Public		Nonprofit		Private		Intl.		National		County		Municipal			
	T	#	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Emergency Response	195	7.5	158	6.6	34	1.4	11	0.5	21	0.9	51	2.1	107	4.5	24	1.0	203	8.5
Damage Assessment	394	15.1	236	9.9	61	2.6	50	2.1	5	0.2	105	4.4	167	7.0	70	2.9	347	14.5
Service Interruption	145	5.6	74	3.1	9	0.4	33	1.4	0	0.0	45	1.9	48	2.0	23	1.0	116	4.9
Communication	191	7.3	141	5.9	60	2.5	50	2.1	0	0.0	117	4.9	105	4.4	29	1.2	251	10.5
Disaster Relief	259	10.0	155	6.5	57	2.4	31	1.3	1	0.0	90	3.8	104	4.4	48	2.0	243	10.2
Medical Care/Health	142	5.5	68	2.8	31	1.3	49	2.1	1	0.0	33	1.4	76	3.2	38	1.6	148	6.2
Restore/ Repair	166	6.4	100	4.2	19	0.8	11	0.5	0	0.0	45	1.9	51	2.1	34	1.4	130	5.4
Recovery	265	10.2	149	6.2	77	3.2	33	1.4	2	0.1	122	5.1	105	4.4	30	1.3	259	10.9
Mitigation	104	4.0	83	3.5	17	0.7	8	0.3	3	0.1	39	1.6	56	2.3	10	0.4	108	4.5
Aids/Services/Policies	113	4.3	68	2.8	4	0.2	0	0.0	0	0.0	30	1.3	29	1.2	13	0.5	72	3.0
Legal/Enforcement	83	3.2	47	2.0	7	0.3	22	0.9	1	0.0	39	1.6	33	1.4	3	0.1	76	3.2
Donation /Fundraising	385	14.8	141	5.9	68	2.8	51	2.1	2	0.1	114	4.8	64	2.7	80	3.4	260	10.9
Political Activities	51	2.0	39	1.6	7	0.3	2	0.1	1	0.0	22	0.9	23	1.0	2	0.1	48	2.0
Religious Ceremony	36	1.4	19	0.8	17	0.7	0	0.0	0	0.0	13	0.5	14	0.6	9	0.4	36	1.5
Earthquake Research	38	1.5	23	1.0	4	0.2	0	0.0	1	0.0	17	0.7	5	0.2	4	0.2	27	1.1
Others	34	1.3	47	2.0	6	0.3	10	0.4	0	0.0	26	1.1	21	0.9	16	0.7	63	2.6
TOTAL	2601	100.0	1548	64.9	478	20.0	361	15.1	38	1.6	908	38.0	1008	42.2	433	18.1	2387	100.0

5.1.3.2 2009 Typhoon Morakot Response System

In the Morakot response system, the reported disaster response activities during the first three weeks are sorted into sixteen categories, listed in the first column of Table 27. A total of 1,960 transactions were observed in the system, 14.5% or 284 of which were emergency response activities, the largest proportion among the categories. The second largest proportion, 12.5% or 254 of the transactions was the actions of donating and fundraising in the system. Damage assessment followed a close third, with 244 or 12.4% of the transactions. In terms of the

characteristics of the actors involved in the transactions, 69.6% were public, 21.6% were nonprofit, and the rest of 8.9% were private.

Compared to the ChiChi response system, disaster response activities were more frequently observed in the Morakot response system. This difference might be caused by the nature of the two events. In the ChiChi Earthquake, most of the damage was caused by the shock that occurred on September 21 1999, and the search and rescue tasks were primarily implemented in the first 72 to 100 hours. The response system then quickly shifted to the relief assistance and recovery process. In contrast, the continued rainfall brought by Typhoon Morakot gradually caused flooding, landslides, and damage to transportation infrastructure that developed over several days. Emergency response activities, such as search and rescue, lasted more than one week, as the situation continued to unfold in the remote and mountain areas.

Table 27 Frequency Distribution of Transactions by Jurisdiction and Source of Funding: 2009 Typhoon Morakot

Type of Transactions	# of Transactions		# of Actors by Funding Source						# of Actors by Jurisdiction Level								Total Number of Actors	
			Public		Nonprofit		Private		Intl.		National		County		Municipal			
	T	#	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Preparation	46	2.3	26	1.7	2	0.1	2	0.1	0	0.0	4	0.3	19	1.2	7	0.5	30	2.0
Emergency Response	284	14.5	127	8.3	18	1.2	5	0.3	3	0.2	36	2.4	65	4.3	46	3.0	150	9.8
Damage Assessment	244	12.4	150	9.8	24	1.6	17	1.1	4	0.3	58	3.8	57	3.7	72	4.7	191	12.5
Service Interruption	140	7.1	60	3.9	15	1.0	10	0.7	0	0.0	33	2.2	42	2.8	10	0.7	85	5.6
Communication	131	6.7	110	7.2	31	2.0	15	1.0	2	0.1	65	4.3	50	3.3	39	2.6	156	10.2
Disaster Relief	229	11.7	106	7.0	70	4.6	24	1.6	1	0.1	74	4.9	74	4.9	51	3.3	200	12.1
Medical Care/Health	69	3.5	46	3.0	35	2.3	0	0.0	0	0.0	12	0.8	54	3.5	15	1.0	81	5.3
Reconstruction	200	10.2	96	6.3	21	1.4	18	1.2	0	0.0	64	4.2	35	2.3	36	2.4	135	8.9
Recovery	98	5.0	67	4.4	32	2.1	13	0.9	0	0.0	66	4.3	35	2.3	11	0.7	112	7.3
Aids/Service/Policies	108	5.5	92	6.0	17	1.1	2	0.1	0	0.0	34	2.2	29	1.9	48	3.1	111	7.3
Legal/Enforcement	38	1.9	30	2.0	2	0.1	1	0.1	1	0.1	16	1.0	14	0.9	2	0.1	33	2.2
Donation / Fundraising	245	12.5	65	4.3	47	3.1	28	1.8	8	0.5	75	4.9	38	2.5	19	1.2	140	9.2
Political Activities	73	3.7	49	3.2	6	0.4	0	0.0	0	0.0	17	1.1	19	1.2	19	1.2	55	3.6
Religious Ceremony	10	0.5	6	0.4	5	0.3	0	0.0	0	0.0	3	0.2	5	0.3	3	0.2	11	0.7
Weather Monitoring	17	0.9	4	0.3	0	0.0	0	0.0	0	0.0	4	0.3	0	0.0	0	0.0	4	0.3
Others	28	1.4	27	1.8	4	0.3	0	0.0	0	0.0	13	0.9	12	0.8	6	0.4	31	2.0
TOTAL	1960	100.0	1061	69.6	329	21.6	135	8.9	19	1.2	574	37.6	548	35.9	384	25.2	1525	100.0

5.2 INTERACTIONS THAT CROSS BOUNDARIES

Since no single organization can solve public problems on its own, interactions across sectoral and jurisdictional boundaries are inevitable. Responding to large-scale disaster events requires efforts from actors from all sectors across all jurisdiction levels. This study considers the extent to which the organizations in the two response systems interacted with the organizations that belonged to different sectors or jurisdictional levels.

5.2.1 1999 ChiChi Earthquake Response System

This study defines interactions as any exchange, for example, a request for information or the delivery of resources, between two or more organizations that was reported in the newspaper under analysis. All interactions were coded as non-directional, meaning the goal was to simply identify links between organizations involved in the interaction. In the ChiChi Earthquake response system, 2,632 interorganizational interactions were observed. When analyzed by source of funding of the actors involved, the interactions can be categorized as intra-sectoral or inter-sectoral. Table 28 shows that 71.4% of interorganizational interactions were intra-sectoral, most of which occurred in the public sector. The remaining 28.6% were inter-sectoral, 18.8% of which occurred between public and nonprofit organizations.

Table 28 Frequency Distribution of Interorganizational Interactions by Sector: 1999 ChiChi Earthquake

	Types	Frequency	Sub-total (%)	Total (%)
Intra-sectoral Interactions	Public : Public	1,638	1,878 (71.4)	2,632 (100)
	Nonprofit : Nonprofit	184		
	Private : Private	56		
Inter-sectoral Interactions	Public : Nonprofit	494	754 (28.6)	
	Public : Private	214		
	Nonprofit : Private	46		

When analyzed by level of jurisdiction, 1,341 or 50.9% of the interactions were performed by organizations that shared the same jurisdiction level. As Table 29 indicates, 29.4% of the interactions were performed within the national level, and 20.1% were preformed within the county level. Moreover, 49.1% of the interactions were carried out by two organizations that belong to different jurisdiction levels. For instance, 27.5% of interactions occurred between

organizations from the national and county levels, and 13.3% occurred between the organizations from the county and municipal levels.

Table 29 Frequency Distribution of Interorganizational Interactions by Jurisdiction: 1999 ChiChi Earthquake

	Types	Frequency	Sub-total (%)	Total (%)
Intra-Jurisdictional Interactions	Intl. : Intl.	1	1,341 (50.9)	2,632 (100)
	National : National	775		
	County : County	529		
	Municipal : Municipal	36		
Inter-Jurisdictional Interactions	Intl. : National	34	1,291 (49.1)	
	Intl. : County	12		
	National : County	723		
	National : Municipal	171		
	County : Municipal	351		

This study also cross-analyzed the interactions by source of funding and level of jurisdiction (Table 30). When the interactions performed within the public sector were analyzed, 766 or 46.8% occurred between organizations that operated at the same jurisdiction level, and 872 or 53.2% operated across jurisdictions. However, when the intra-sectoral interactions within the nonprofit and private sectors were analyzed, a higher proportion of intra-jurisdictional interactions was identified. For example, 70.1% of the interactions within the nonprofit sector occurred between organizations from the same jurisdictional level, and 91.1% of interactions within the private sector were performed between organizations from the same jurisdictional level. This result shows that nonprofit and private organizations, when interacting with organizations in their respective sector, were more likely to interact with organizations from the same jurisdictional level.

Table 30 Distribution of Interorganizational Interactions by Sector and Jurisdiction: 1999 ChiChi Earthquake

	Types	Frequency	Sub-total (%)	Total (%)
Public : Public	National : National	407	766 (46.8)	1,638 (100)
	County : County	333		
	Municipal : Municipal	26		
	Intl. : National	22	872 (53.2)	
	Intl. : County	4		
	National : County	434		
	National : Municipal	139		
	County : Municipal	273		
Nonprofit : Nonprofit	National : National	103	129 (70.1)	184 (100)
	County : County	26		
	Intl. : National	3	55 (29.9)	
	Intl. : County	1		
	National : County	48		
	National : Municipal	3		
Private : Private	National : National	30	51 (91.1)	56 (100)
	County : County	21		
	National : County	5	5 (8.9)	
Public : Nonprofit	Intl. : Intl.	1	256 (51.8)	494 (100)
	National : National	137		
	County : County	108		
	Municipal : Municipal	10		
	Intl. : National	7	238 (48.2)	
	Intl. : County	7		
	National : County	153		
	National : Municipal	26		
	County : Municipal	45		
Public : Private	National : National	78	111 (51.9)	214 (100)
	County : County	33		
	Intl. : National	2	103 (48.1)	
	National : County	66		
	National : Municipal	3		
	County : Municipal	32		
Nonprofit : Private	National : National	20	28 (60.9)	46 (100)
	County : County	8		
	National : County	17	18 (39.1)	
	County : Municipal	1		

5.2.2 2009 Typhoon Morakot Response System

In the Morakot response system, 1,567 interorganizational interactions were observed. Table 31 indicates that 78.4% of the interorganizational interactions were intra-sectoral, most of which were performed within the public sector. The remaining 21.6% were inter-sectoral interactions, of which 16.0% occurred between the organizations from the public and nonprofit sectors. Compared to the 71.4% of intra-sectoral interactions identified in the ChiChi response system, a higher proportion of intra-sectoral interactions were observed in the Morakot response system.

Table 31 Frequency Distribution of Interorganizational Interactions by Sector: 2009 Typhoon Morakot

	Types	Frequency	Sub-total (%)	Total (%)
Intra-sectoral Interactions	Public : Public	1,117	1,229 (78.4)	1,567 (100)
	Nonprofit : Nonprofit	103		
	Private : Private	9		
Inter-sectoral Interactions	Public : Nonprofit	251	338 (21.6)	
	Public : Private	72		
	Nonprofit : Private	15		

Table 32 shows the distribution of interorganizational interactions by jurisdictional level. This table shows results that are similar to those observed in the ChiChi case, with 49.3% of the total number of interactions classified as intra-jurisdictional interactions, and the remaining 50.7% classified as inter-jurisdictional interactions.

Table 32 Frequency Distribution of Interorganizational Interactions by Jurisdiction: 2009 Typhoon Morakot

	Types	Frequency	Sub-total (%)	Total (%)
Intra-Jurisdictional Interactions	Intl. : Intl.	3	772 (49.3)	1,567 (100)
	National : National	431		
	County : County	292		
	Municipal : Municipal	46		
Inter-Jurisdictional Interactions	Intl. : National	29	795 (50.7)	
	Intl. : County	1		
	Intl. : Municipal	0		
	National : County	363		
	National : Municipal	133		
	County : Municipal	269		

Table 33 shows interactions sorted by sources of funding and jurisdiction levels. The results are similar to those observed in the ChiChi response system, except for the distribution of interactions within the nonprofit sector. In the 2009 Morakot response system, 48.5% of interactions within the nonprofit sector were performed by organizations from different jurisdiction levels, a proportion that was substantially higher than the 29.9% observed in the 1999 ChiChi response system.

Table 33 Frequency Distribution of Interorganizational Interactions by Sector and Jurisdiction: 2009 Typhoon Morakot

	Types	Frequency	Sub-total (%)	Total
Public : Public	Intl. : Intl.	1	555 (49.7)	1,117 (100)
	National : National	322		
	County : County	212		
	Municipal : Municipal	20		
	Intl. : National	14	562 (50.3)	
	Intl. : County	1		
	National : County	234		
	National : Municipal	91		
	County : Municipal	222		
Nonprofit : Nonprofit	National : National	21	53 (51.5)	103 (100)
	County : County	25		
	Municipal : Municipal	7		
	Intl. : National	8	50 (48.5)	
	National : County	7		
	National : Municipal	13		
	County : Municipal	22		
Private : Private	National : National	7	7 (77.8)	9 (100)
	National : County	2	2 (22.2)	
Public : Nonprofit	Intl. : Intl.	2	133 (53.0)	251 (100)
	National : National	59		
	County : County	53		
	Municipal : Municipal	19		
	Intl. : National	6	118 (47.0)	
	National : County	70		
	National : Municipal	19		
	County : Municipal	23		
Public : Private	National : National	18	20 (27.8)	72 (100)
	County : County	2		
	Intl. : National	1	52 (72.2)	
	National : County	44		
	National : Municipal	6		
	County : Municipal	1		
Nonprofit : Private	National : National	4	4 (26.7)	15 (100)
	National : County	6	11 (73.3)	
	National : Municipal	4		
	County : Municipal	1		

5.3 DEVELOPMENT OF THE SYSTEMS

The formation of a network is a dynamic process. As the two emergency situations developed, the responders reacted to problems at different rates and times. Cumulatively, the response systems grew. This section utilized the data to analyze the organizational rate of entry and the growth of the two reported response systems during the three weeks after the disaster events.

5.3.1 Rate of Entry

Organizations in the system have different functions, responsibilities and decision making processes. Consequently, organizations enter the system at different times. This section analyzes the rate of entry by identifying the number of new organizations that entered the system on each day during the three weeks that followed the disasters. The entry of these organizations into the response system was plotted by date, level of jurisdiction, and by source of funding.

5.3.1.1 1999 ChiChi Earthquake Response System

Figure 8 shows the number of new organizations that entered the ChiChi Earthquake response system every day during the three weeks under analysis. The most active days occurred between 21 September 1999 and 23 September 1999, in which 744 or 64% of the organizations entered the system. The rate of entry dropped significantly three days after the earthquake occurred.

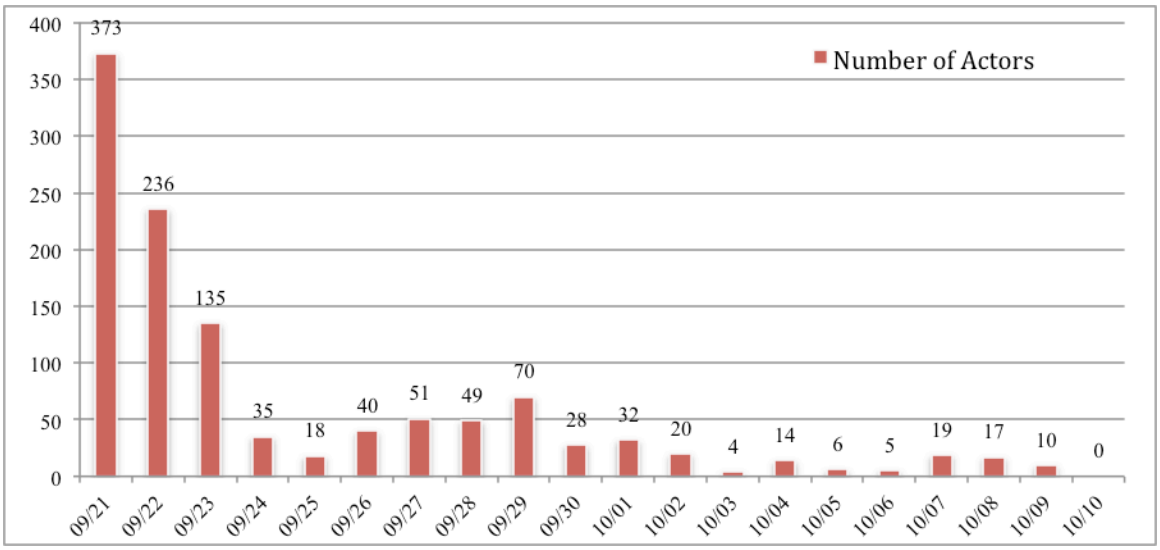


Figure 8 **Rate of Entry of New Organizations into the Response System by Date: 1999 ChiChi Earthquake, 9/21/99 – 10/10/99**

When the rate of entry was analyzed by source of funding, the results show that organizations from the public, nonprofit and private sectors had similar rates of entry. Figure 9 indicates that most of the public, nonprofit and private organizations entered the system during the first three days after the earthquake.

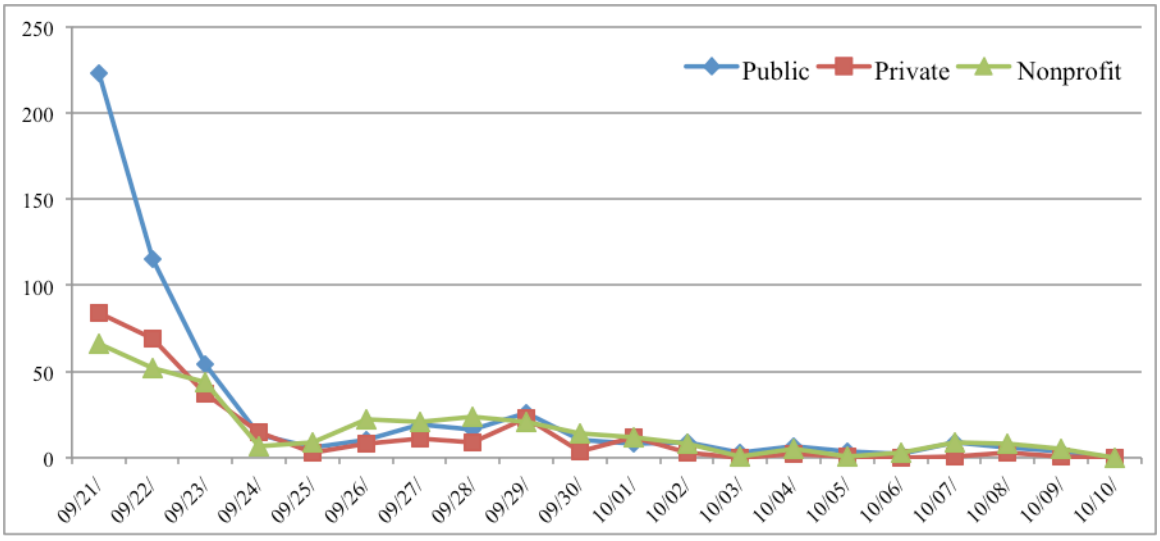


Figure 9 **Rate of Entry of New Organizations into the Response System by Date and Funding Source: 1999 ChiChi Earthquake, 9/21/99 – 10/10/99**

Figure 10 presents the number of new organizations identified in the system by jurisdiction. It indicates that organizations classified as county quickly responded to the earthquake on the first day. The organizations that operated at the national level became involved in the response system at a slower rate. Different from the organizations that operated at national and county levels, the peak of entry rate for organizations classified as municipal was on the second day, 22 September 1999.

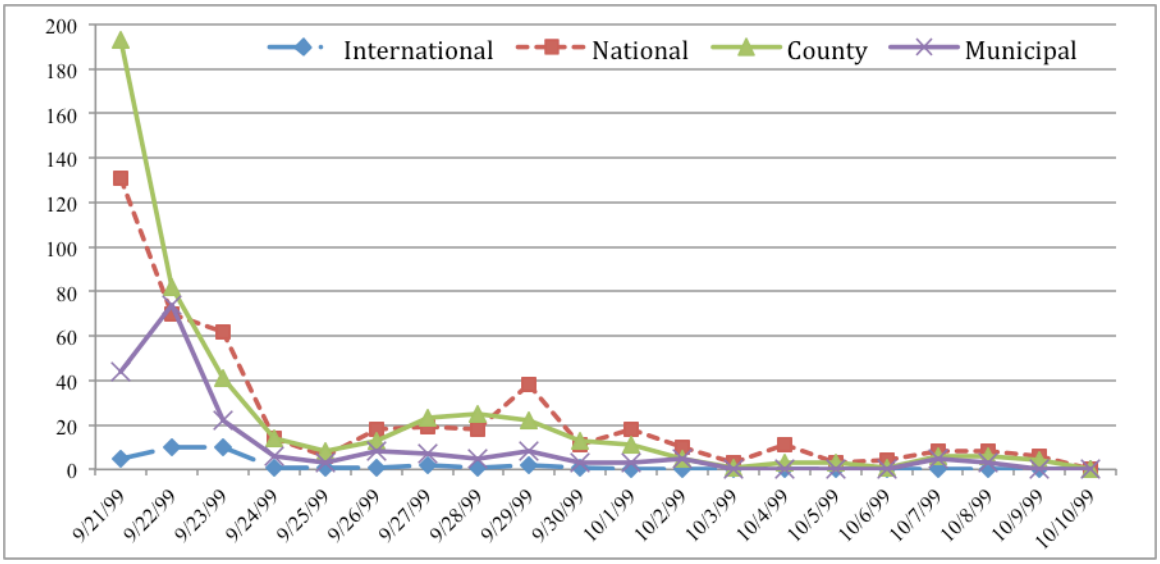


Figure 10 Rate of Entry of New Organizations into the Response System by Date and Jurisdiction: 1999 ChiChi Earthquake, 9/21/99 – 10/10/99

5.3.1.2 2009 Typhoon Morakot Response System

The organizations in the Morakot response system had different rates of entry than the organizations in the ChiChi response system. Figure 11 indicates that organizations gradually entered in the system between 6 August 2009 and 14 August 2009. Even though the Sea Typhoon Alert was issued on 5 August, there were no active preparation measures taken until the storm approached on 6 August 2009. The peak rate of entry was on 9 August 2009, the fourth

day after the Typhoon Morakot landed. Generally speaking, the rate of entry decreased, but the slope was not as sharp as the one observed in the ChiChi response system.

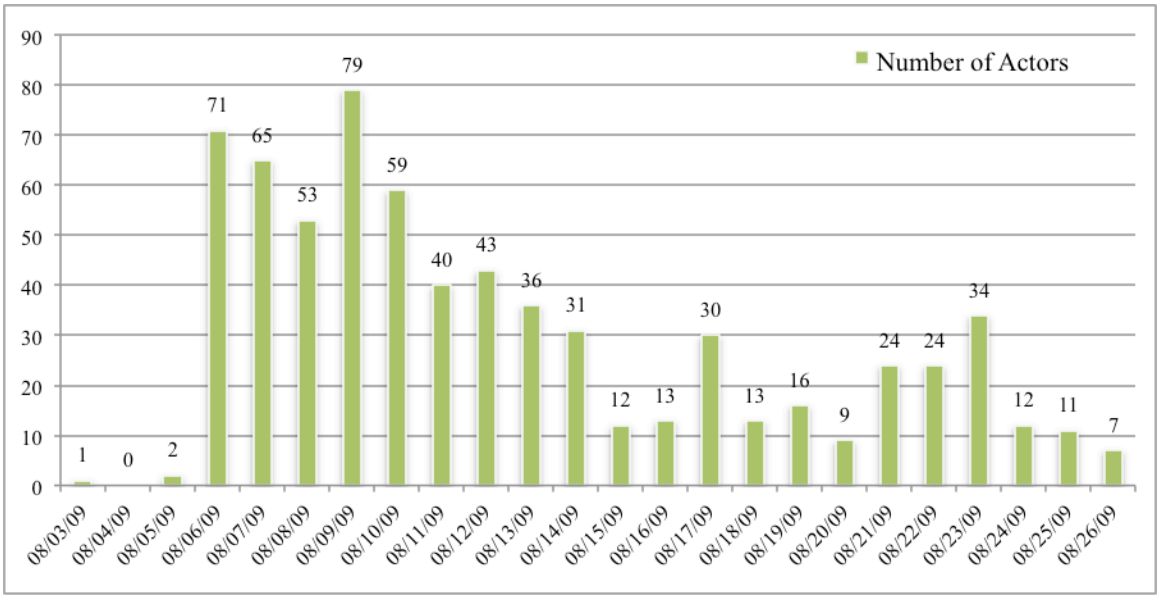


Figure 11 Rate of Entry of New Organizations into the Response System by Date: 2009 Typhoon Morakot, 8/3/09 – 8/26/09

Figure 12 shows the organizational rate of entry for the Morakot response system by source of funding, which indicates that organizations from different sectors had different rates of entry. The public organizations actively entered the system between 6 August 2009 and 10 August 2009, followed by some minor spikes throughout the three weeks. On 23 August 2009, the Tainan County government requested its 31 township offices to report the damages caused by Typhoon Morakot, therefore a spike occurred on that date.

Figure 12 also shows that nonprofit organizations did not enter the system at the exact same time. The first peak occurred on 6 August 2009, where the Typhoon Sea Alert was issued. The second peak was observed on 9 August 2009, where many voluntary search and rescue teams became involved in the system. The most active day for nonprofit organizations occurred on 12 August 2009, where hospitals and some voluntary groups provided relief assistance. The

final peak was observed on 22 August 2009, where some tourist industry associations started discussing the recovery of the tourism industry.

Private organizations also entered the response system at a different rate. The first peak for private organizations occurred on 7 August 2009, when private transportation companies reported business interruptions due to the storm. The second peak was observed on 9 August 2009, when private companies provided information to customers who had products damaged by the flooding. On 17 August 2009, some private companies were reported to have begun to provide post disaster recovery assistance and merchandise services.

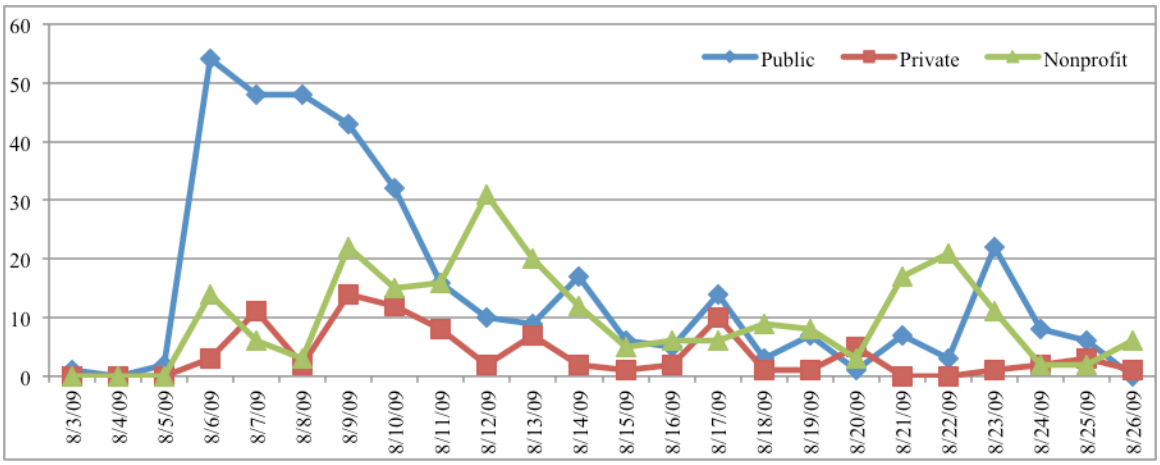


Figure 12 Rate of Entry of New Organizations into the Response System by Date and Funding Source: 2009 Typhoon Morakot, 8/3/09 – 8/26/09

Figure 13 indicates that organizations from different jurisdiction levels had varied rates of entry. The data shows that organizations classified as county entered the system faster than those from other jurisdictions. The most active day for county organizations occurred on 6 August 2009, when the Central Weather Bureau issued the Typhoon Alert and the county governments were responsible for deciding whether school and work would canceled on the next day.

The organizations that operated at the national level started to enter the response system on 7 August 2009. Most of organizations classified as national, however, entered the system

between 9 August 2009 and 13 August 2009. The final peak occurred on 17 August 2009, where national organizations began to engage in post disaster recovery tasks.

The most active days for organizations classified as municipal occurred between 7 August 2009 and 9 August 2009. As previously described, the 31 townships that caused the peak observed on 23 August 2009 were from Tainan County. In terms of the rate of entry for foreign organizations, they did not enter the system until 12 August 2009, one week after the typhoon landed. Compared to the record observed in the ChiChi Earthquake response system, the international responders entered the Typhoon Morakot response system relatively late.

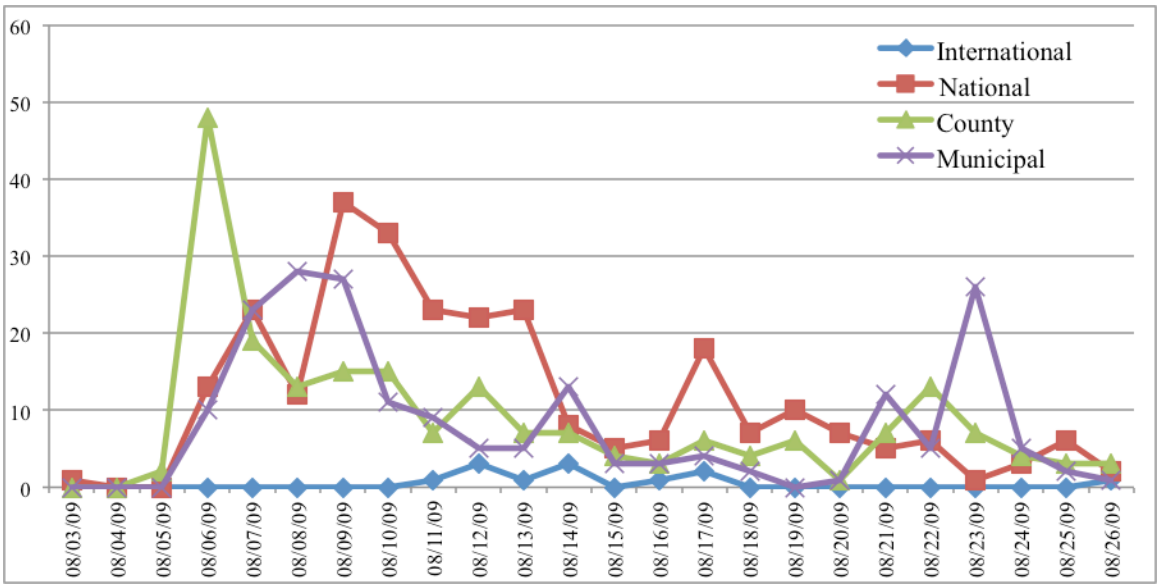


Figure 13 Rate of Entry of New Organizations into the Response System by Date and Jurisdiction: 2009 Typhoon Morakot, 8/3/09 – 8/26/09

5.3.2 Growth of the Systems

When the accumulated frequency of the new organizations entered in the system on each day throughout the three weeks was calculated, the results indicate the response systems had different rates of growth. Figure 14 represents the cumulated percentage of new organizations that entered

the ChiChi response system, which reached the 80% capacity on 28 September 1999, eight days after the earthquake. However, it took the Morakot response system longer to reach 80% capacity. Figure 15 indicates that it reached the 80% capacity on 18 August 2009, thirteen days after the Typhoon landed.

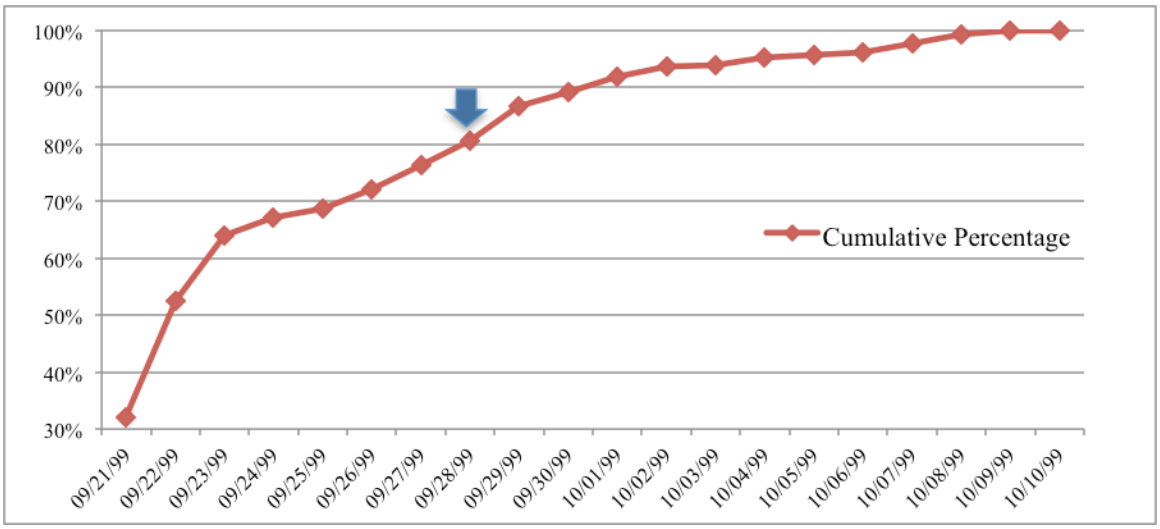


Figure 14 Growth of the 1999 ChiChi Earthquake Response System as a Cumulative Percentage of Participating Organizations, 9/21/99 – 10/10/99

The difference in the rates of growth between the two disaster response systems indicates that the organizational actors sensed the risk and the needs of the systems at different rates. This difference may be due to nature of the earthquake and typhoon events, which generated impacts at different rates. The difference could also be due to the speed at which information was shared and the effectiveness of communication among organizations in the two response systems.

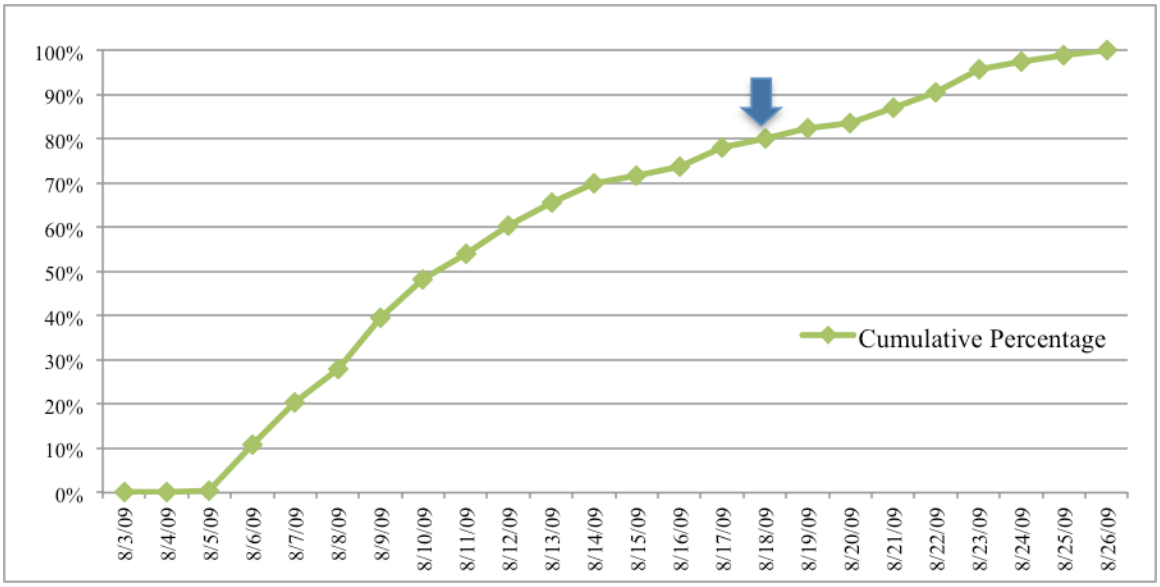


Figure 15 **Growth of the 2009 Typhoon Morakot Response System as a Cumulative Percentage of Participating Organizations, 8/3/09 – 8/26/09**

5.4 EVOLUTION OF NETWORK STRUCTURES

The structure of disaster response networks evolves when actors decide to join the system or interact with other organizations. Each organization may choose to work with different partners, or they can exchange resources and information to improve the problem solving process. The interactions that are exchanged between individual organizations can influence the structure of the network, which can be considered a self-organizing process that evolves over time. This section analyzes the evolution of the reported network structures in the two studied disaster response systems with three measures: density, diameter, and number of components.

5.4.1 Network Density

According to Wasserman and Faust (1994), the density of a network is "the proportion of possible lines that are actually present in the [network]. It is the ratio of the number of lines present to the maximum possible" (p. 101). The possible score of density ranges from 0 to 1. If there are no lines present among nodes, the density is zero; if all possible lines are present, the value of density is 1. In an open response system where a large number of organizations are involved, the scores of density tend to be low, which do not necessarily imply the low effectiveness of the network. This section plots the scores of density of the two disaster response systems by date to reveal the change of density in the two systems during the first three weeks.

The overall density of the ChiChi response system was 0.003. When the network density is analyzed by date, the data show that the density slightly increased during the three weeks of response operations. Figure 16 shows that two spikes occurred on 4 October and 10 October 1999. On 4 October 1999, the Taiwan Ministry of Education coordinated the Bureau of Education in 7 county governments and 13 universities to provide mental health care service to the impacted students. On 10 October 1999, there were 6 interactions among 12 organizations reported in the system. As the number of reported transactions and actors dropped in the last few days of the third week, a small number of interactions may have increased the density values.

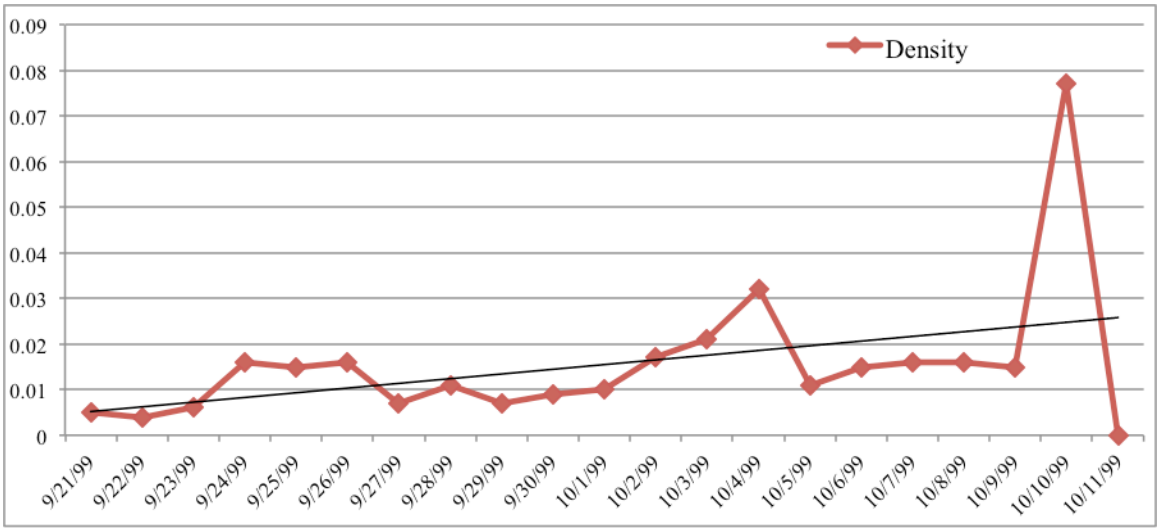


Figure 16 **Density Scores of the 1999 ChiChi Earthquake Response System by Date, 9/21/99 – 10/10/99**

The overall density of the Morakot response system was 0.005, which was slightly higher than the overall density of the ChiChi response system. Figure 17 shows the trend of the network density scores for the Morakot response system, which indicates a more progressive increase in density than that observed in the ChiChi Earthquake system. The density reached the highest score on 25 August 2009, where the Executive Yuan coordinated 12 ministries to establish the Morakot Post-Disaster Reconstruction Council. As the number of reported transactions and actors decreased in the third week, ministry meetings caused the higher score of density of the system.

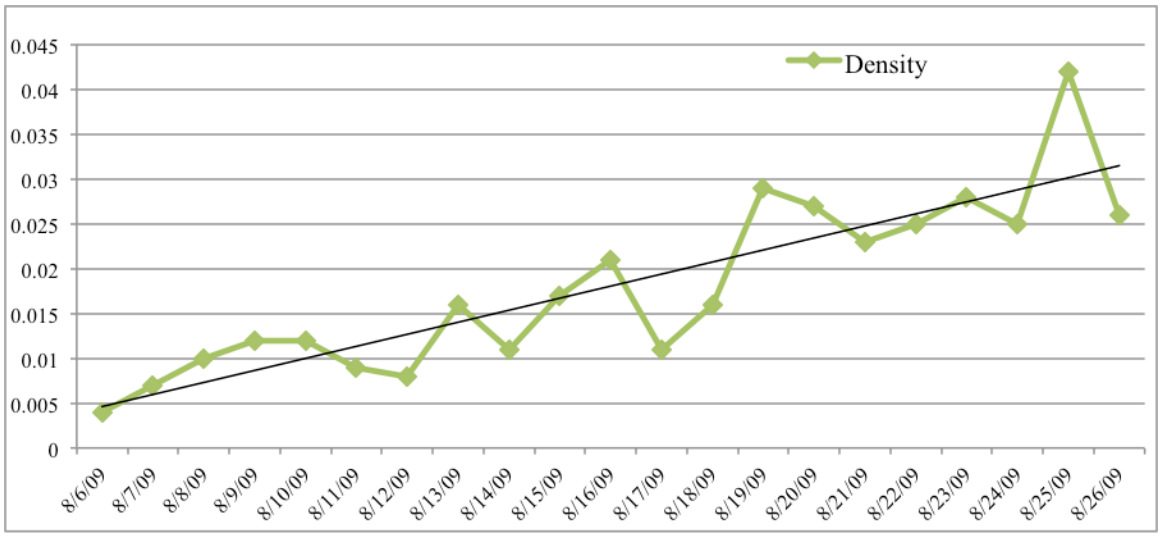


Figure 17 Density Scores of the 2009 Typhoon Morakot Response System by Date, 8/3/09 and 8/26/09

5.4.2 Network Diameter

Diameter is a measure used to evaluate the distance between the nodes in a network. In a disaster response system, organizations may search for information and resources needed to solve problems or deliver services. A shorter distance between organizations means higher accessibility to resources and lower traveling costs to transmit information from one organization to another. Wasserman and Faust (1994) defined diameter as "the length of the largest geodesic between a pair of nodes" (p. 111). As geodesic refers to the shortest path between two given nodes, the diameter measure reveals how far apart the farthest two nodes in the network are. The maximum diameter of a network could be number of nodes minus 1, and if the network is completely connected its diameter is 1 (p. 112).

Figure 18 shows the change of diameter scores between 21 September 1999 and 11 October 1999. It shows the trend of decreasing diameter in the ChiChi response system. The diameter score was 9 on 21 September 1999, when the actors were the most actively involved in

the system. The diameter reached its highest score of 14 on 29 September, when a group of new actors entered in the system. This result suggests that as the system evolved, the distance between organizations began to decrease. The organizations increasingly interacted with other organizations in the system, which reduced the diameter of the response system.

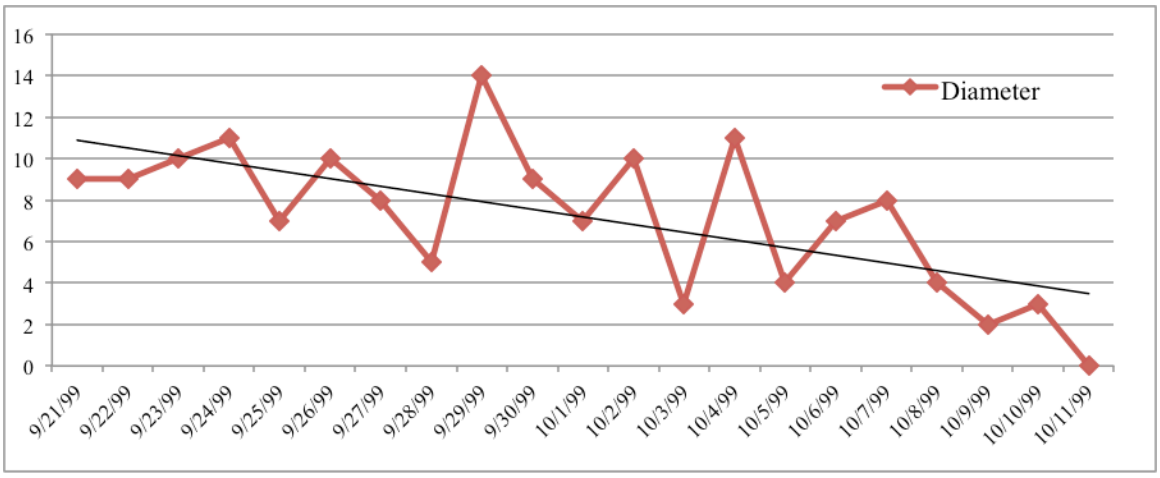


Figure 18 Diameter Scores of the 1999 ChiChi Earthquake Response System by Date, 9/21/99 – 10/10/99

Figure 19 indicates the change in diameter scores for the Morakot response system. Two spikes were observed, which occurred on 9 August and 12 August 2009, when a significant number of new organizations entered the system. On these dates, the distance between organizations increased. Compared to the ChiChi response system, the Morakot response system had a milder decrease in diameter scores. These results indicate that some organizations in the Typhoon Morakot response system did not integrate themselves into the network.

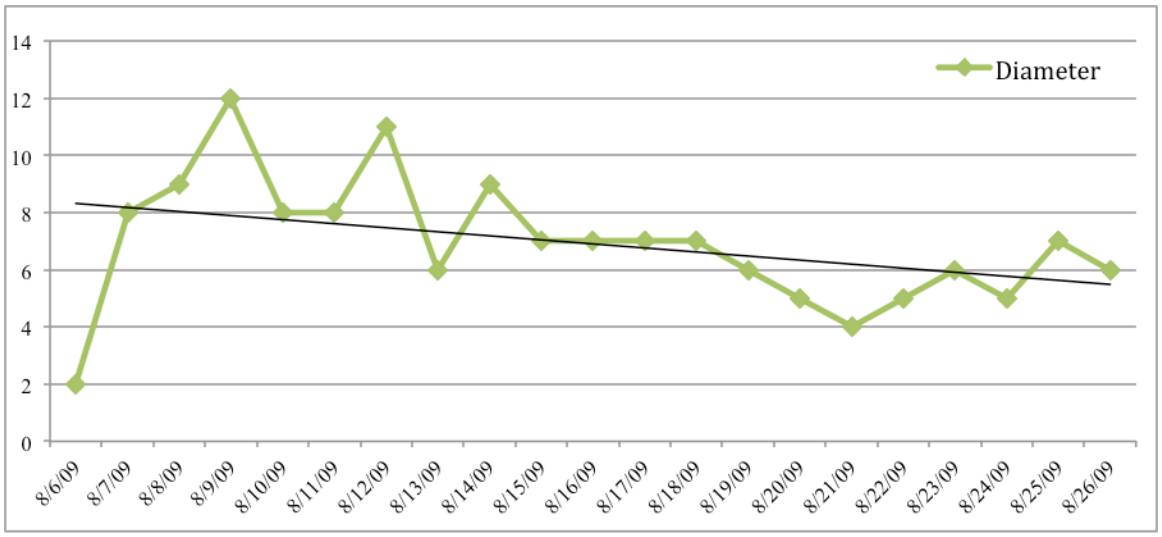


Figure 19 **Diameter Scores of the 2009 Typhoon Morakot Response System by Date, 8/3/09 – 8/26/09**

5.4.3 Network Components

According Wasserman and Faust (1994: 109), a component is "a subgraph in which there is a path between all pairs of nodes in the subgraph, and there is no path between a node in the component and any node not in the component." In a response system, a component means three or more organizations worked together as a close group that fully connected with each other, but none of those organizations interact with the actors outside of the group. The presence of components in disaster response systems suggests that some organizations may choose to respond to a specific problem by interacting within a closed group in which the resources and information can be rapidly exchanged and shared. However, the resources and information possessed within the group were not available to the organizations outside of the group, even though they operated in the same response system.

Figure 20 shows the daily number of components in the ChiChi Earthquake response system. The highest number was 15, which occurred on 28 September 1999. The average

number of components was 7.4. The figure shows a trend of decreasing number of components in the system. This finding indicates that the organizations increasingly interacted with other actors outside of their isolated groups, which improved the system's ability to distribute resources and information throughout the system.

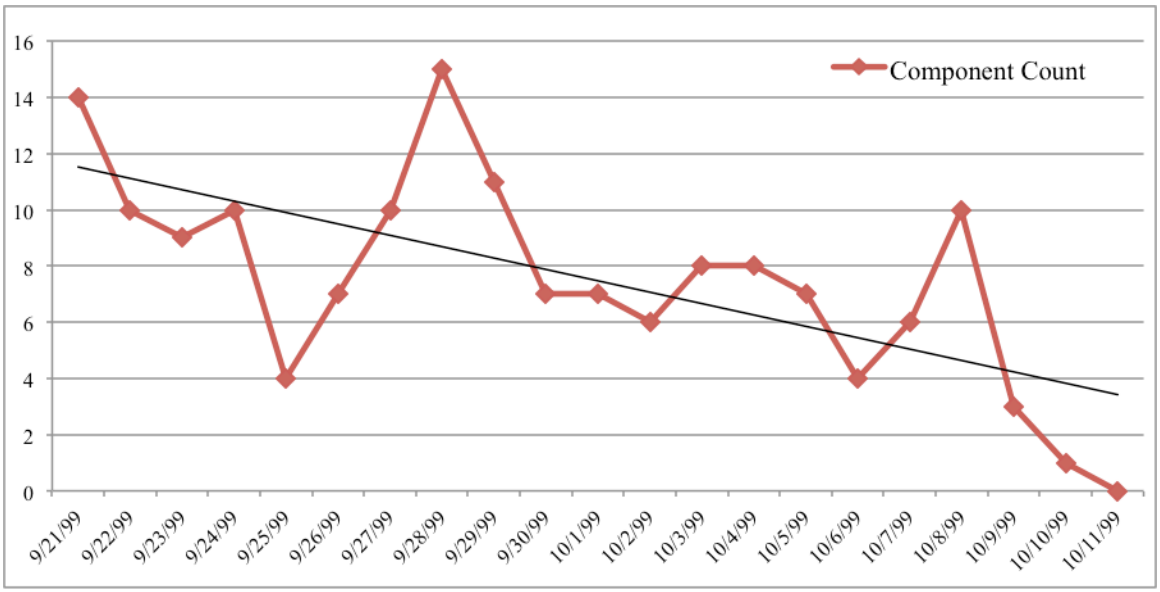


Figure 20 Number of Components in the 1999 ChiChi Earthquake Response System by Date, 9/21/99 – 10/10/99

In the Morakot response system, the average number of components was 5.43, which was lower than the ChiChi response system. Except for the extreme low and extreme high value, the number of components on 16 August 2009 and 17 August 2009, generally speaking, the system shows a decreasing trend in the number of components during the three weeks of response operations (Figure 21). This mild change in the number of components suggests that some organizations in the system remained disconnected from the primary response network.

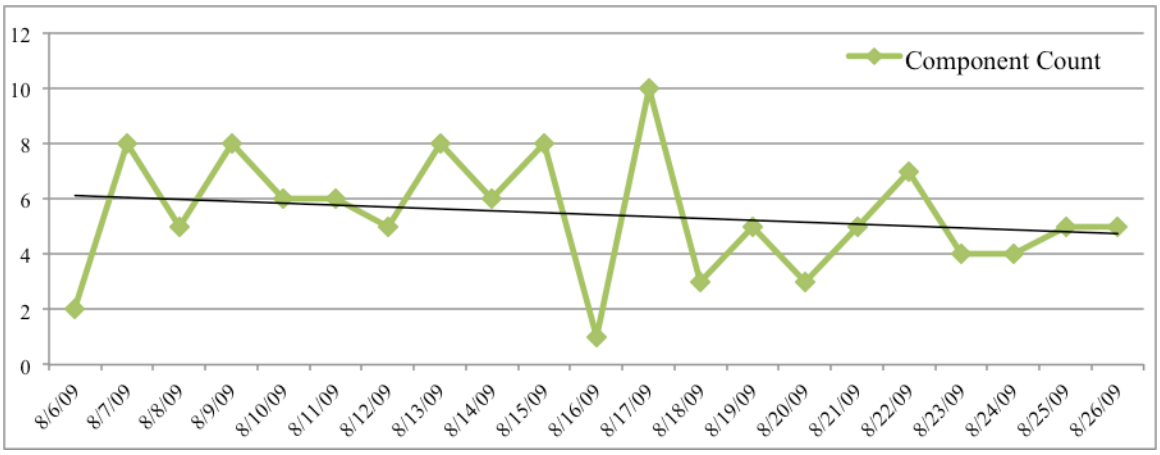


Figure 21 Number of Components in the 2009 Typhoon Morakot Response System by Date, 8/3/09 – 8/26/09

5.5 CONCLUSION

The findings presented in this chapter indicate that the disaster response networks contained organizational actors from sectors and jurisdiction levels that were outside of Taiwan's formal disaster management plan. These organizations interacted with each other to perform a variety of tasks. During the three weeks that followed each disaster event, the network structures developed and evolved with the interaction processes.

I also identify the structural similarities and differences between two disaster events. In terms of the similarities organizations funded by the public sector were the largest in number and occupied the central positions in the networks for both events. Examining the composition of the response systems by jurisdictional levels, the organizations that operated at the national level were not only present in the highest proportion; they were also the most central actors in the networks. Second, the analysis of the content of the transactions showed that damage/need

assessment, donating/fundraising, emergency response, disaster relief, and recovery were the most frequently reported activities in both response systems. Third, more than 70% of the reported interorganizational interactions were intra-sectoral interactions. Finally, the density, diameter and component results indicate that the structure of the response networks evolved over time. Both networks showed trends of increasing density, and decreasing diameters and number of components during the three weeks of observation.

The analytical results also showed dissimilarities between the network structures. First, when compared to the ChiChi case, county governments possessed higher betweenness centrality scores in the Typhoon Morakot event. This means county governments played a more significant role in the Morakot response system. Second, the results show that public sector organizations were more like to interact and perform response activities in the Morakot response system. Third, the results indicate that the systems had different patterns of growth. This result suggests that the actors in the two systems had different capacities to recognize and respond to risk. In the ChiChi response system, most organizations entered during the three days after the disaster. In contrast, the organizations that entered the Morakot response system did so at a much more varied rate, taking almost two weeks for most of the actors to enter the system.

6.0 FACTORS THAT INFLUENCED THE FORMATION OF GOVERNANCE NETWORKS

While most governments assume that a well-designed disaster management system can promote the performance in times of emergency (Schneider 1995), no institutional structure can fully overcome the uncertainties caused by disaster. Responding to large-scale disaster events requires the collective efforts of various actors, and many have different institutional backgrounds. The actors in a response system must have the capacity to interact to solve collective problems.

This study views the formation of interorganizational networks in the context of disaster response as a dynamic process that requires shared cognition, communication, and coordination among actors. Pre-designed disaster management structures, such as formal institutions, information and communication technology, and the attributes of the actors in the system, will not be the only factors that influence network formation. The formation of networks is also influenced by factors that emerge during the interaction process.

Using data collected from semi-structured interviews and official documents, this chapter addresses two research questions. First, to what extent did pre-existing structural factors influence the formation of interorganizational networks, and second, to what extent did the interaction process factors such as norms, culture and other factors also influence the formation of interorganizational networks. In order to maintain the interviewees' confidentiality, the

responses quoted in the text are cited according to an individual identification number. Please refer to Appendix A for the respondent's organization affiliation and management position.

6.1 STRUCTURE FACTORS

In this study, structure refers to the relatively stable and permanent patterns of relationships that exist in a social system (Scott and Davis 2007: 26). Thus, structural factors include formal institutions, designed information and communication technology, and the attributes of organizations that persist over time. These structural factors routinely and continuously support the disaster response activities carried out in the system. Table 34 summarizes the influences of structural factors on the formation of interorganizational networks.

Table 34 Summary: Influence of Structure Factors

Factors	Promote/ Constrain	Effects	Number of Response	Respondent ID*
Formal Institutions	Promote	Provide legal mandate to guide organizations to interact with the other actors	12	G1; G2; G3; G6; G8, G11; G15; G16; G17; G20; G23; G24
	Constrain	Inhibit organizational cognitive processes	3	G1; G3; G8
		Increase the cost of transmitting information	3	G1; G14; G15
		Divided and fragmented responsibility	6	G3; G6; G7; G10; G15; G17
Actor Attributes	Promote	Public organizations possess the authority and gain trust from other actors	4	G1; G3; G9; N1
	Constrain	Different institutional background creates conceptual distance between actors	8	G1; G7; G10; G12; G14; G21; P1; P2
Information and Communication Technology	Promote	Allow actors sharing information beyond geographical distance	5	G1; G3; G7; G10; G15
		Improve decision making process	3	G7; G10; G23

* Refer to Appendix A for respondent's ID, organizational affiliation, and position.

6.1.1 Formal Institutions

Formal institutions refer to the laws and mandates that identify the legal responsibilities and functions of organizations in the response system. For example, the National Emergency Plan and the Disaster Protection and Prevention Act were the two major institutions that stated and defined the legal structure of Taiwan's disaster response system in 1999 and 2009 respectively. The formal institutions can facilitate, but at the same time, constrain interactions among actors.

6.1.1.1 Formal Institutions that Promoted Interaction

Formal institutions, such as legislative laws and rules, influence the formation of interorganizational networks by guiding an organization's decision on when and with whom to interact. The behavior of government agencies' is guided by the principle of "administration by law." The content of the emergency response related legislative laws and administration rules significantly influence governmental agencies' response activities in the system.

When the ChiChi Earthquake occurred, the National Emergency Plan was the major formal administrative rule that was available in the system. Although the Plan had provided limited guidance, one respondent indicated "it at least encouraged the ministries to station themselves in the Central Emergency Operations Center immediately right after the Earthquake" (Respondent G21). The Plan guided the Executive Yuan to activate the Central Emergency Operation Center where the ministries interacted and coordinated in response to the situation.

Formal institutions played a more significant role in promoting interactions during the response to Typhoon Morakot. When Typhoon Morakot approached Taiwan, the government agencies were required to react and interact with other organizations by the Disaster Prevention and Protection Act. According to another respondent, "when the Central Weather Bureau issued

the Sea Typhoon Alert, we followed the law to activate Emergency Operation Center, and all related departments stationed in…it was not just for responding to Typhoon Morakot, we performed the same action whenever we received alerts" (Respondent G1). The emergency response center is a critical space for facilitating the horizontal communication across functions within governments. As Respondent G3 stated, "during emergency response, we reported information to the Central Emergency Operations Center, and when we need any assistance from other ministries, we would make the request through the Center as well. To be honest, it's hard to communicate across ministries directly. Therefore, the Central Emergency Operations Center is critical for coordination." A county government respondent also expressed similar comments: "the departments that are responsible for roadways, rivers, and telecommunication would send a staff to the county government's Emergency Operations Center, so we can distribute tasks to each department to solve problems based on the incoming information" (Respondent G17).

With appropriate design, formal institutions provide organizations in a response system with specific timing and space to interact with others. Even under an emergency situation, most governmental agencies tend to act without violating the law. The trust in the legal system helps these organizations to share a similar understanding of their respective roles and functions in the system without spending a long time to build personal trust during an emergency situation.

6.1.1.2 Formal Institutions that Constrained Interaction

Formal institutions could constrain interactions by inhibiting the organizational cognitive processes used to perceive potential risks. Operating under the legal structure, organizations tend to evaluate risk by focusing on the listed criteria written in the law, but fail to recognize the signs of risks that are not identified. As Respondent G1 stated, "[w]hen preparing for Typhoon Morakot, we followed the law and took the same actions as we did for other typhoons. Typhoon

Morakot was very different from the previous typhoons in terms of scale and rainfall pattern, but we were not mentally prepared for it." The inhibited cognition prevented organizations from taking necessary actions, for example, by mobilizing the resources needed to reduce the damage caused by the impact of the disaster event.

Legal mandates could also inhibit effective interactions during emergencies by increasing transaction costs. Directed by the principle of "administration by law," government organizations were required to follow traditional hierarchies to access information or resources. For example,

> *"[w]hen the ChiChi Earthquake occurred, my troops got ready and were dispatched to rescue people in 10 minutes, it was a spontaneous decision…After the ChiChi Earthquake, the government passed the law which requires local government to apply for military's assistance during emergency situation. Without the application, the military could not send out our troops"(Respondent G14).*

A respondent from a county government also indicated a similar problem: "when we applied for the military's assistance, the request would go through the hierarchical system all the way to the top. The final decision would be made and delivered all the way down to us. This procedure took a long time" (Respondent G1).

In modern governments, responsibilities and functions are usually shared by multiple agencies. While formal institutions clearly state the scope of responsibility for each organization to hold the organizations accountable, they may also prevent organizations from taking on responsibilities beyond their legal mandate. For example, if a hill collapses, based on the location and cause, the incident can be the responsibility of the Ministry of Transportation and Communication, the Council of Agriculture, the Council of Indigenous Affairs, or the Ministry of Economic Affairs (Respondent G10). Therefore, when a compound disaster occurs, there is no single organization that is fully responsible for the situation. Respondent G10 continued, "[n]one

of them has the full responsibility, and all of them share a part of the responsibility of the incident of collapse." A system could fail to respond to the emergency situation, but no organization was responsible for the failure. As Respondent G1 stated, "they would defend itself as legit, it was no one's fault. We can only say the current legal system is not sound."

6.1.2 Attributes of Actors

The attributes of organizations also influence the formation of networks in disaster response systems. The attributes discussed in this section refer to the characteristics of organizations, for example, their institutional background, formal function, and position in the system that is designated by formal rules (Ostrom 2005). The attributes of an organization can affect its position and exercise of power in the system.

6.1.2.1 How Actor Attributes Promoted Interactions

The disaster response systems under analysis were composed of organizations with different institutional backgrounds. Based on the network analysis results that were presented in chapter five, Table 35 shows that in both disaster events, most interorganizational interactions, almost 90%, occurred either within the public sector, or between the public organizations and non-public organizations.

Table 35 Comparison of Frequency Distributions of Interorganizational Interactions by Sector: 1999 ChiChi Earthquake and 2009 Typhoon Morakot

Types	1999 ChiChi Earthquake		2009 Typhoon Morakot	
	Frequency	%	Frequency	%
Public : Public	1,638	62.2	1,117	71.3
Public : Nonprofit	494	18.8	251	16.0
Public : Private	214	8.1	72	4.6
Nonprofit : Nonprofit	184	7.0	103	6.6
Private : Private	56	2.1	9	0.6
Nonprofit : Private	46	1.7	15	1.0
Total	2,632	100.0	1,567	100.0

Disaster response is considered one of the government's responsibilities and functions in Taiwan's society. The interview data show that the government agencies tended to perform their functions within the governmental system. Even under the situation of chaos, intuitively, the governmental agencies seek for resources and assistance from the government agencies. As stated by Respondent G9, "it's government's responsibility. You need to figure out how to get things done, even without the nonprofit organizations' assistance."

It is easier for public organizations to make connections with other organizations. The actors in the system tend to trust government agencies that possess the authority to implement policies and carrying out legal measures. The reliability and stability of public authority can also facilitate interactions (Cook, Hardin, and Levi 2005). As Respondent G1 stated, "because we are public employees too, we knew how the governmental system operates. It was much easier for us to pick up the tasks that the local government had failed to perform. And, since we put out the sign of Pingtung County Government, other organizations and local people believed that we had the authority to do what we were doing."

Organizations that were assigned a legal position in the formal disaster response system were more likely to possess the power to interact with other organizations. For example, Taiwan

Red Cross is the only non-governmental organization that was legally designated to perform disaster relief tasks in the Taiwanese disaster response system. Taiwan Red Cross formed a post-disaster service alliance that coordinated the efforts of more than fifty nonprofit organizations. As Respondent N1 reported, "we got so many nonprofit organizations to join us, because Taiwan Red Cross has the advantage of communicating and negotiating with the government and the military. It's very important, as through this coordination mechanism we can get resources and all participating nonprofit organizations could get in this response system to provide services."

6.1.2.2 How Actor Attributes Constrained Interactions

Differences in institutional backgrounds could also constrain the interactions between organizational actors. In the situation of emergency response, the organizations with different institutional backgrounds might work together under the requirement of legal mandates. However, the quality and effectiveness of communication could be diminished due to the institutional barriers. Thus, organizations have to overcome the gap of conceptual distance when communicating and interacting with each other (Axelrod and Cohen 2000).

This problem was observed in the interactions between the military and administrative agencies after both the ChiChi Earthquake and Typhoon Morakot. Even though the military and the civil administrative agencies are considered a part of government, these two systems did not interact with each other smoothly. Different from the bureaucratic structure, the military is designed as a closed system to maintain its secrecy and independence. These institutional barriers constrained the interactions between the military and the administrative system. As Respondent G1 reported, "when we applied for the military's assistance, we would not know their decision making procedure, and would not know how much and when we would get the supplies we applied for. However, from the military's perspective, they also had no idea what

exactly were the problems we were facing and how we were going to utilize the supplies they provided. There was just a barrier between the demand and supply sides."

6.1.3 Information and Communication Technology

Information and communication technology are not just tools for organizations. As Scott and Davis (2007) stated, "they are more appropriately treated as a 'dimension of structural design' – a means for communication and coordination" (p. 136). The design of information and communication technology represents how a system exchanges and processes information among components.

Before the ChiChi Earthquake, the information and communication technology available in the system included landline phones, cell phones, and 119 (Fire) and 110 (Police) emergency phone systems. The fire department, police department and the military were equipped with independent radio communication systems (Respondent G21).

After the ChiChi Earthquake, the government made investments to improve its information and communication technology (ICT). When Typhoon Morakot occurred, in addition to the ICT mentioned above, the disaster response system was also equipped with satellite cellphones, and portable communication stations that could secure communication channels. The government also developed Emergency Management Information System and applied Geographic Information System for decision making purposes.

6.1.3.1 Role of Information and Communication Technology in Network Formation

During a disaster response, "information is the key" (Respondent G15). Decision makers need to possess situational information to take appropriate actions to solve problems. "With information,

we can allocate resources and manpower efficiently," as reported by Respondent G3. Due to the geographical distance, however, organizations cannot exchange information without using ICT. The application of ICT allows organizations in the system to spread and receive essential information with actors at different locations, and to improve the quality of decision making.

An example from the ChiChi Earthquake event shows the importance of ICT in transmitting essential information that is critical for the formation of effective response networks. "Due to the disconnection of telecommunication, we could not send out messages. The Taichung Government didn't realize how seriously our town (WuFong Township) was damaged, and it even asked us to help another township. Six days later, the County government finally recognized that our town was seriously damaged, so they sent some people to help us" (Lee and Liao 2001: 397).

In a situation of disaster response, ICT are essential for reconstructing the chain of command system. The two studied cases indicate that the original command systems were usually disrupted by the impact caused by large-scale disasters. As a mayor of a township in Taichung County stated, "[u]nder the situation of no water, no electricity, no transportation and no telecommunication, I realized I was a commander only if there was a functional telecommunication system (Hsieh 2001: 450)." Without ICT to deliver information, the commanders' orders cannot go anywhere. "It would be much easier to rebuild the command system with functional communication technology," as suggested by Respondent G3.

Advanced ICT also can enhance the quality and effectiveness of communication among organizational actors, which would help to improve their decision making and interaction processes. For example, geographic information systems (GIS) allow decision makers from different departments to share and interpret geographic data within a unified platform.

Respondent G3 and Respondent G7 confirmed the utility of GIS for integrating the information and data from different departments. According to Respondent G3, "You always need a map in the battle field. The traditional maps didn't contain all the information we need. GIS allows us to cooperate and integrate the data from multiple agencies. With the real-time data of mountains, rivers, bridges and roads presented in the same system, it's much easier to make decisions."

Another ICT that facilitates interaction and communication among actors is the Emergency Management Information System (EMIS). The design of EMIS aims to promote information sharing and communication among organizations across jurisdiction levels and administrative functions. Respondent G10 explained the importance of the EMIS. He stated, "[w]e aimed to collect the real-time information of disaster situation through EMIS. Ideally, people would expect the government of each jurisdiction level to integrate all the information in their jurisdiction then report it up to the higher-level government. In reality, they are too busy to integrate information. Therefore, we wanted each agency, regardless of its jurisdiction level, to provide its situation report to EMIS directly. By doing so, we can sort and analyze the data by jurisdictions and by functions on the information system" (Respondent G10).

6.2 PROCESS FACTORS

While emergency response actions always take place within an existing structure of rules and resources, these processes also work to produce new rules that influence the patterns of interaction in a social system. The interorganizational interactions that occur in disaster response systems are not only influenced by the formal structure, but they are also shaped by the factors that emerge in the process of interactions.

The experiences of responding to the two studied disaster events showed that the existing formal structure had been disrupted by the disasters. A respondent who experienced the ChiChi Earthquake event stated, "the administrative system was totally shot down, and the communication channels were all disconnected…we could not operate with the original plan. Same in the townships, they could not function as normal either. Even if we could have placed the order, they did not have the personnel to implement (Respondent G24)." Similar situations were observed in the Typhoon Morakot event, "…disasters damaged the information and communication system, and the original command system" (Respondent N1).

Rather than following formal institutional structures, disaster response is often a self-governing process in which responders adjust and evolve to gradually restore order to the system. It is critical to learn what factors make the system operate and evolve, especially in situations where the formal institutions were not sufficient to guide the response activities. This section identifies the factors that emerged during the process of interaction, including norms, culture, utilization of ICTs, social relationships and leadership. Table 36 summarizes the influences of process factors. The following sub-sections discuss how these factors influence the formation of network in the context of emergency response.

Table 36 Summary: Influence of Process Factors

Factors	Promote/ Constrain	Effects	Number of Response	Respondent ID*
Norms	Promote	Emergent norms of humanitarianism and altruism encourage voluntary involvement	25	G1; G2; G6; G9; G11; G13; G17; G18; N1; N2; N3; N4; N5; N6; N7; N8; N9; N10; N11; N12; N13; N14; P1; P2; P3
	Constrain	Conflict between the norm of bureaucracy and the need for emergency response	5	G9; G11; G14; G22; G23
Culture	Promote	Culture of exploring external resources	3	G23; G24; N7
	Constrain	Culture difference between fire departments and voluntary search and rescue teams	4	G17; G21; N3; N8
		Culture barriers between administrative agencies and the military	1	G14
		Political cleavages and polarization	9	G12; G14; G17; G19; G21; G23; G24; N6; N7
		Culture barrier between different ethnic groups	9	G1; G12; G13; G22; G24; N6; N7; N10; N11
Role of Relationship	Promote	Pre-existing relationship facilitate interactions	13	G6; G9; G11; G15; G20; G23; N1; N2; N6; N7; N10; N14; P1
		Individual connections	10	G4; G10; G11; G13; G15; G17; N3; N8; N7; N10
		Members and clients of NPOs	8	G11; G18; N4; N6; N11; N12; N13; N14
Utilizing of Information and Communication Technology	Promote	Adapt to available ICTs, including radio, TV, and social media	10	G1; G3; G6; G9; G13; G15; G16; G19; N2; N7
	Constrain	Lack of resilience	4	G2; G10; G12; G14
		Lack of human resources	7	G2; G7; G9; G10; G11; G19; G22
		Constrained communication loops	4	G3; G15; G21; N3
Leadership	Promote	Making judgment and direct the organization	7	G1; G2; G4; G9; G14; G15; N10
		Overcome legal limitations	2	G4; G6
	Constrain	Lack of professional knowledge	1	G15
		Personal misjudgment	1	G17

* Refer to Appendix A for respondent's ID, organizational affiliation, and position.

6.2.1 Norms

According to the formal institutions, the government is the primary actor that is responsible for emergency response activities. However, in the both cases, this study found that a large number of nonprofit and private organizations engaged in the response system. The involvement of these organizations emerged in the process, and could not be explained by the formal structural factors. Based on the findings from interviews, I attempt to explain the phenomena from the perspective of emergent norms in the response process.

Norms are informal rules that guide social behavior. Even though norms are usually not written in law, individuals who violate norms are often considered social outcasts. Disasters, as "agents of chaos," facilitate changes in the behavior of social actors (Harris 1990). During disaster response, the normative structure is altered, and certain norms emerge to guide behavior. This section discusses the norms that emerged in Taiwan's disaster response system during the studied events, and how these norms influenced the formation of the networks in the systems.

6.2.1.1 How Norms Promoted Interaction

As Dennis E. Wenger stated, "the alteration in traditional function and values which occur in disaster settings place high priority on humanitarianism, mutual support, and general helping behavior" (1978: 33). During disaster response, the norm of altruism is often exaggerated. The social system encouraged the efforts of providing aid and services to the victims. This emergent norm was also observed in Taiwan's disaster management system. One respondent stated, "we didn't need to make request for help through legal process. As long as they have the supplies and resources, people were willing to help" (Respondent G18). Another respondent supported this

point, indicating: “I think the Taiwanese are very generous, when disasters occurred, they would come to me to offer assistance voluntarily” (Respondent G23).

Research conducted by Quarantelli and Dynes show that people tend to respond to disasters through collective organization, rather than acting as individuals (Stallings 1978: 89). In the two studied cases, many nonprofit and private organizations engaged in the response system in addition to the governmental agencies that are legally responsible for disaster response activities. These organizations either temporarily extended the scope of their services or expanded their capacity to perform disaster-related tasks.

When asked about the motivation for becoming involved in disaster relief tasks, respondents from different organizational backgrounds provided different answers. The voluntary search and rescue teams considered it their mission to perform those tasks (Respondents N3, N8). The respondents from the nonprofit organizations with religious background are usually associated the behaviors with their religious beliefs (Respondents N4, N12, N13, N14). There are also respondents from nonprofit organizations that stated that they had the capacity and responded to the need for assistance (Respondents N2, N7). The respondents from private companies suggested that their actions were driven by the norms of fulfilling corporate social responsibilities (Respondents P1, P2).

When these organizations entered the response system and performed their respective tasks, they built interorganizational relationships with other actors. There were several factors that influenced the organizations with which they elected to interact that will be discussed in the subsequent sections of this chapter. However, one factor mentioned by the interview respondents is associated with the norms of legitimacy. Legitimacy implies being accepted as the appropriate agent for carrying out an activity (Dynes 1978: 51). When nonprofit organizations and private

companies engaged in the response system, they needed to fulfill the expectations from their constituencies, such as their donors, clients and the public. Therefore, these organizations tended to work with the partners that had the authority to perform disaster related tasks, such as government agencies or international organizations like the Red Cross.

6.2.1.2 How Norms Constrained Interaction

Although the norms of humanitarianism and altruism identified in the response systems promoted interaction among organizations, they also constrained interorganizational interactions. While the large number of organizations engaged in the response system for the purpose of fulfilling social norms and public expectations, some organizations started to compete for public attention. The competition relationships emerged and inhibited coordination and cooperation among organizations. As Respondent G23 indicated, "[w]e need a certain degree of management on those organizations. Sometimes they impeded our actions. Meanwhile, there were competitive relationships among them. Everyone wants to be involved "(Respondent G23).

There was also a conflict between the norm of bureaucracy and the need for emergency response (Schneider 1995). The government using the bureaucratic structure mainly carried out the disaster response tasks. However, bureaucratic organizations are established to address public problems with clearly defined objectives and to operate on the basis of clearly designated procedures. In an emergency, government agencies are supposed to take the action and coordinate with organizations that possess the resources needed to solve problems.

In practice, however, bureaucratic employees were unable to respond to the emergency situation quickly or effectively for two reasons. First, it took too much time for information to flow through the bureaucratic system. "We as street-level bureaucrats need to follow the rules from higher authority. When they gave us too many restrictions or didn't interpret the rules

clearly, we lose our capacity to deal with emergency situations" (Chen 2001a: 338). Second, even if they were authorized to make decisions, bureaucratic employees tended to be conservative. According to Respondent G23, "we are limited by laws. Bureaucrats are afraid to be investigated. Even though they are allowed to take special measures during an emergency, they tend not to use the right. You don't know if you would get in trouble afterwards (Respondent G23)." The norm of bureaucracy prevented the government agencies from initiating interactions or building effective communication and coordination relationships with other organizations.

6.2.2 Culture

Culture describes "the pattern of values, beliefs, and expectations more or less shared by the [members in the system]" (Scott and Davis 2007: 23). Through semi-structured interviews, this study observed the organizational cultures that encourage cooperation. However, culture also acted as a barrier among organizations, which inhibited their ability to interact. This section discusses how culture promoted and constrained interactions among organizations.

6.2.2.1 How Culture Promoted Interaction

The organizations that possessed the culture of exploring resources outside of its organizational boundary were more willing to adapt the strategy of cooperation. For example, the respondents that possessed social work backgrounds all emphasized the importance of seeking resources from external sources (Respondents G23, G24, N7). "Social work is about coordinating resources," one of the respondents stated. "Seeking for help" was their move when they confronted the

challenge of disaster disruption. In both events, the social affairs departments of local governments played the role of connecting resources with nonprofit organizations.

6.2.2.2 Types of Culture that Constrained Interaction

After a disaster, both the fire department and the voluntary search and rescue teams act as first line responders. According to laws, during an emergency situation, the voluntary search and rescue teams need to work with the fire department and accept the fire department's direction. However, respondents from voluntary search and rescue teams expressed their discontent with the regulation. These respondents believed that they should "have the autonomy to perform the missions" (Respondents N3, N8). From the fire department's perspective, "of course they can save lives under emergency situations. But when they work as an organization, we need manage it. We need to know where people go" (Respondent G21).

Traditionally, fire departments were only responsible for fire fighting activities. In the last decade, fire departments were gradually expected to perform all types of search and rescue tasks, but fire fighters did not receive the training needed to perform these tasks. One respondent commented about this situation, "the problem is they (professional search and rescue teams) think they have better professional skills, so they would not accept the fire department's lead. These organizations are wild" (Respondent G17). Cultural barriers constrained their interactions.

Cultural barriers were also observed between the military and the administrative systems. The interactions between the military and administrative systems were not only constrained by the institutional design, but also by the culture differences. The respondents with military backgrounds indicated how difficult it was for the military to work with administrative agencies, "[t]he way we carry out tasks was just very different from that of the administrative agencies. We would just focus on how to achieve the mission effectively, but the local government

agencies always needed to ask for their supervisor's approval [which delayed our decision making process]" (Respondent G14).

Beyond organizational culture, the political culture in Taiwan's society also influenced the formation of the disaster response networks. Political cleavages and polarization constrained the interorganizational interaction in the response system. Organizations that belonged to different political positions were less likely to interact. One respondent analyzed the problem of Taiwan's disaster management system and suggested that culture was the key issue. "It is an irrational society and our political parties act viciously against each other (Respondent G14)." Another respondent more specifically indicated the point, stating that "when the commanders of the central and county government were belong to different political parties, it's more likely that the central government would skip the county government and communicate with the townships directly. This situation was more significant in the ChiChi Earthquake event" (Respondent G19).

Cultural differences between ethnic groups could also constrain interaction and communication among organizations. People with different ethnic backgrounds may speak a different language, or they may present a different reaction when they face an emergency situation. For example, after the ChiChi Earthquake, a group of foreign laborers who could not speak Chinese were looking for relief services. Due to the language and culture barriers, the local Taiwanese people could not understand their needs and thought they were attempting to rob and loot (Respondents G1; G13; G22; G24). During the response to Typhoon Morakot, many of impacted areas were located at, or around, Taiwan's indigenous communities. Due to cultural and language barriers, the emergency responders, who are usually from a Han background, could not communicate these victims, who were from indigenous backgrounds, or provide them with services that met the unique needs of their communities (Respondents G12; N6; N10; N11).

6.2.3 Role of Relationships

Even though formal institutions have provided the standard procedure for information exchange during emergency situations, organizations do not always follow the rules in practice. Ideally, information about the disaster situations should be collected and exchanged through the emergency operating center of each jurisdictions level. However, as one respondent stated, "in practice, it's too slow. The mayor of the town would just call the magistrate directly" (Respondent G23).

As Respondent G15 stated, "I think the core of a disaster response system is people... In Chinese society, building relationships is more important than knowing the standard operating procedures." Several respondents addressed the importance of relationships during the emergency responses in several aspects. First, positive relationships can enable things to be done more easily. Respondent G15 provided an example, "[w]hen working with someone with whom you are familiar, things can be done with one phone call. However, if you don't know each other, it may take you 10 phone calls and the problem still remains unsolved." Some respondents indicate, in practice, they choose to work with the ones they trust or have positive relationships, "[o]therwise, you will get nothing done. They wouldn't take your requests seriously" (Respondent G16).

Second, relationships promote information exchange. In practice, commanders do not only receive information through the formal information and communication system, but also through the informal channels that are built based on personal networks. These personal communication channels can supplement the decision making process when the formal information and communication system fails. As one of the respondents stated, "the government officials at the local level usually know many local informants, representatives, and local

legislators. These people have their ways to get information. Therefore, even if the formal communication channel was not functioning, we still can get information through those informal sources" (Respondent G23).

Third, the respondents also indicated that "knowing each other" was critical for coordination and cooperation. "People sitting in the same room don't necessary talk with each other," Respondent G15 commented. Friendships and acquaintanceships promoted coordination and cooperation by building trust. Coordination and cooperation means the organizations will lose a certain degree of control on their resources. It requires trust for organizations to commit to a cooperative relationship. As one respondent indicated, "most cooperative relationships have a historical context, they don't just pop out from nowhere" (Respondent N7).

The interorganizational interactions were influenced by the relationships present at both organizational and individual levels. This section identifies the role of relationships that affect the formation of networks based on the practices observed in the two studied events. First, the pre-existing interorganizational relationships promoted interactions. Second, an individual's personal social connections can be utilized to achieve the organizations' goal. Third, the members and clients of nonprofit organizations can be considered as an organization's niche for building connections in the disaster response system.

6.2.3.1 Pre-existing Interorganizational Relationships Promoted Interactions

Pre-existing relationships facilitate information exchange and cooperation between organizations. A pre-existing relationship means that organizations already possess each other's contact information and can easily identify the key contacts needed to access information and resources. Interactions that occurred prior to the disaster events helped the organizations to develop trust. When disasters occur, organizations knew to which organization they could go for assistance.

The effects of pre-existing relationships are frequently observed in the interactions among the public and nonprofit organizations. During the disaster responses operations under study, nonprofit organizations served as complementary supporters to governmental functions and filled gaps in provision of government's services. Many of these nonprofit organizations also worked with government agencies to deliver social services before the disasters occurred. Therefore, when these nonprofit organizations wanted to engage in the response system, they had the advantage of already knowing key persons in the government (Respondents N2; N3; N6; N7; N12; N14).

For example, the Association of Digital Culture Taiwan was the only nonprofit organization that entered several Emergency Operations Centers and worked with the governments to collect disaster situation information from social media. When I asked how the Association got access to the government agency, a respondent from the Association said, "our association has been working with the county government on projects, so we have built good relationships with them. When Typhoon Morakot occurred, we thought there was something we could do to help, so we contacted them directly" (Respondent N2). Similar interaction patterns were mentioned by respondents from other nonprofit organizations (Respondents N4, N6, N7, N12, N14).

The effect of pre-existing relationships was also applicable when government agencies sought assistance from nonprofit organizations. A respondent that worked in a county government impacted by Typhoon Morakot explained how the pre-existing relationships promoted interaction during disaster emergency: "[o]ur supplies and resources primarily came from the local nonprofit organizations' support. We have been building connections with them

for years. I know which organization to contact with when I need food or other supplies" (Respondent G23).

Pre-existing relationships also promoted cooperation among nonprofit organizations. During Typhoon Morakot, Taiwan Red Cross and several nonprofit organizations launched the "88 Flood Relief Service Alliance" to coordinated post-disaster relief services among nonprofit organizations. The members of the Alliance had worked together after the Sichuan Earthquake in China in 2008. The respondent from Taiwan Red Cross said, "[w]e gathered all partners who worked for the Sichuan Earthquake in China, and established the 88 Flood Relief Service Alliance with the same group of nonprofit organizations" (Respondent N1).

6.2.3.2 Individual Connections

An individual's social network could also facilitate interorganizational connections. Several respondents mentioned that they utilized their personal connections to gain access to resources and information, which helped their organizations achieve their goals. One of the respondents provided an excellent example, "the commander assigned me the mission of setting up the disaster response center from scratch. Under that chaotic situation, it's impossible to do it with the formal procedure. So, I contacted one of my friends in business to help me out" (Respondent G4).

Besides utilizing personal friendships, individual connections may come from previous working experience in the government. Public employees usually shift their positions and work in different departments during a long career. These experiences help them to mobilize resources across administrative boundaries. For example, one respodent described how he sought resources from his own network, "I not only searched for help through the formal administrative structure.

Because I have worked in the [specific] county government, I also asked for their help and they responded much faster than other county governments" (Respondent G24).

6.2.3.3 Members and Clients that Promoted Interactions

The network analysis results show that, in both disaster events, nonprofit organizations actively engaged in the response system. Even though these organizations were not involved in the formal disaster response plan, they could still rapidly organize and react to the emergency situation, effectively mobilize resources, and serve as the complement to government services.

While norms and beliefs can explain the motivation of involvement, the relationship perspective can explain why these nonprofit organizations were able to build connections in the response network. Besides building connections through pre-existing interorganizational relationships, nonprofit organizations also accessed information and mobilized resources through their members and clients. First, nonprofit organizations can collect and access disaster situations directly through their local members and clients. Some nonprofit organizations could enter the impacted area even before government response teams arrived. This was because they could rely on their members and clients to report information that they needed to self-organize and take action. For example, according to the statistical data from 2010, the largest Buddhist group in Taiwan, Tsuzi Foundation, had more than 200 million members, and has trained and certified more than 100,000 volunteers (Liu 2010). These members and volunteers are distributed around the country. When disasters occur, the members and volunteers provide real time information to the Foundation, and even can organize to respond to the emergency immediately in local communities (Respondent N13). The respondents from the Presbyterian Church and World Vision Taiwan also mentioned similar situations (Respondents N6, N11).

Second, nonprofit organizations can mobilize resources and build connections by using their members. Nonprofit organizations are composed of members that have different occupations and social backgrounds, such as business owners, politicians, government officials, and search and rescue team members. The personal networks of these members become assets for a nonprofit organization enabling nonprofit organizations to mobilize resources through their members. For example, a respondent who owns a transportation business and is a member of a major nonprofit organization in Taiwan stated "during Typhoon Morakot, I arranged to import supplies from other countries for the Foundation…. Me and other business owners recognized the mission of the Foundation, and we would contribute to the Foundation voluntarily" (Respondent P3).

Nonprofit organizations can also connect to government agencies through their members that have political or governmental backgrounds. For example, a Buddhist group mentioned "the magistrate and his secretary were converted to Buddhists by our master, so we know each other very well… We could contact with them directly" (Buddhist ChangTsun 2001: 504).

6.2.4 Use of Information and Communication Technology

ICT are often applied to facilitate interorganizational interactions by overcoming the geographical distance that can separate organizations. However, these technologies only perform their function effectively when the organizations have suitable human resources, and when the design of the communication loop can be used to solve problems. In the situation of disaster response, the resilience of ICT should also be taken into consideration.

During the ChiChi event, information and communication technology did not function effectively, as they were damaged by the earthquake shock. Although the Taiwanese government

made investment to improve the ICT system after the ChiChi Earthquake, the study results show that there were still problems present in the system during the response to Typhoon Morakot.

In the following sections, I analyze the failure of ICT in the disaster response system with the socio-technical perspective, and how the problems in the ICT system inhibited the organizational interaction. I also identify how organizations adapted to the problem and utilized ICT that were available in the system during the emergency situation.

6.2.4.1 Failure of Information and Communication Technology in the System

The information and communication systems failed during the disaster response operations in three aspects: lack of resilience, lack of human resources, and constrained communication loops. Then, this section discusses how these problems inhibited organizational interactions.

Lack of resilience

The ICT in the response systems did not perform effectively because they were not resilient to large-scale disasters. In the ChiChi event, the information and communication were disconnected due to the damage to electrical facilities and telecommunication infrastructures. In severely impacted areas, such as Taichung County and Nantou County, the landline phones and cellphones on which most organizations relied for communications failed to function (Chen 2001b: 218; Chang 2001: 360; Liu 2001: 156; Peng 2001: 84).

Emergency responders confronted a similar situation during Typhoon Morakot. Due to the flood and landslides, organizations in the impact area could not be reached through landlines or cellphones (Respondents G7, G16). Although the landline phones were functioning outside of the impact area, the 119 Emergency Report System was overloaded by the massive amount of phone calls that were coming from citizens who wanted to report on a situation or to confirm the

safety of their family. Meanwhile, satellite cellphones could not function due to the heavy rainfall, which blocked the transmission signals (Respondent G2).

Lack of human resources

The lack of suitable human resources to operate ICTs was another problem confronted by the system, especially after Typhoon Morakot. Although the government had invested in a program to equip local governments and communities with satellite cellphones after the ChiChi Earthquake, these technologies did not function as expected. One of the reasons was the lack of maintenance. Since the equipment would only be used in emergency situations, most had stored the phone in a cabinet for years. When they wanted to use the phone during Typhoon Morakot, the satellite phones either had no power or were broken. Another problem was lack of training. The holders did not know how to use the device. It is more difficult to operate a satellite phone than normal a phones. Many holders in local areas did not have the capacity to read and operate the satellite phones (The Disaster Management Expert Consultation Committee 2010: 10).

The lack of human resources was also problematic for the use of the Emergency Management Information System during Typhoon Morakot. The Emergency Management Information was designed for collecting real time information from the organizations in the response system. In practice, however, it was difficult to keep the system updated due to the lack of human resources (Respondents G3, G7, G10, G23). As indicated by Respondent G23, "[u]nder the emergency situation, we needed to focus on solving problems. We don't have the time to update information on computers."

Constrained Communication Loops

The design of the communication loops did not fulfill the need of actors in the system. This problem was observed in both the ChiChi Earthquake and Typhoon Morakot events. In Taiwan's disaster management system, the information required for responding to disasters is distributed to multiple ministries and departments. Each ministry and department develops its own information system to store the information. A decision maker needs to collect pieces of information from several departments to learn the situation. For example, a respondent stated, "I always have difficulty to get the full picture about the roadways in the impacted area…I needed to collect information from several ministries at the national level, and from the county governments to connect the roadways on one map" (Respondent G3).

The communication system barrier was also reported in the disaster field. The fire department, police department, civil service department, the military and other departments all use their own frequencies when they communicate on radios. These departments do not share information through radios when operating in the field. One of respondents stated, "it has been a problem, we can't communicate and share information with other departments on radio. When investigating in the field, we need to know the situations in the area for the safety reason. However, each department only shares information within their own system, the others can't benefit from the information" (Respondent G3). The issue was also mentioned by the voluntary search and rescue organizations. Voluntary groups could not share information with the fire department on their radio when conducting search and rescue missions (Respondent N3).

Inhibited Interactions

Dependency on information and communication technology could inhibit the cognitive process of organizations. Organizations rely heavily on incoming information to make decisions.

When communication technology fails, and organizations receive no incoming information, decision makers may consider this as a lack of demand for assistance. For example, after the ChiChi Earthquake, "because the communication system was broken, we couldn't send out information…the county government didn't provide us assistance until eight days later" (Lee and Liao 2001: 397). The lack of information delayed organizations from interacting and communicating with other organizations.

6.2.4.2 Information and Communication Technology in Use

According to the respondents, landline phones and cellphones were still the most commonly used form of communication technology (Respondents G2, G9, G15, G23, N6, N7). Before the communication system recovered, organizations adapted to use the tools that were available to deliver and exchange information. For example, the radio was one of the communication technology that still functioned after the landline phones and cellphones were disrupted. Many organizations and emergency responders used radios for communication during the ChiChi Earthquake and Typhoon Morakot responses (Respondents G2, G6, G12, N3, N7, N8, N13).

When advanced communication technology was not available, organizations adapted to use basic tools to communicate, for example, using the megaphone, face-to-face communication or listening to radio broadcasts (Respondent G18). One respondent stated, "during the ChiChi Earthquake response, we drove police cars, and fire trucks with megaphones to disseminate information (Respondent G1)." Some respondents described how they communicated with other organizations face to face in the field (Respondents G17, N7).

During the emergency situation, organizations usually received information from multiple formal and informal sources. A respondent stated, "we also collect information by watching TV news, when we see the situations we didn't know, we will check...Some citizens

also reported situations to the TV stations, and they will transfer this information to us" (Respondent G10). However, TV news tended to repeat and exaggerate the situation, which could mislead and twist the organizations' decision making processes (Respondent G1).

The use of information from social media was one of the major adaptations of the government during Typhoon Morakot. Because the 119 emergency report system was overloaded by the massive volume of incoming phone calls, citizens shifted their demand for information to cyberspace. People reported situations and asked for information on social media, such as Twitter, Facebook, Pluck and Blackboard System. Starting with the Tainan County government, then also at the Central Emergency Operations Center, the government cooperated with the Association of Digital Culture Taiwan to collect information from social media (Respondent N2). A respondent from county government mentioned, "during Typhoon Morakot, we utilized the Internet to recruit volunteers and post what resources we need. The Internet helped us to communicate with the public and keep information updated" (Respondent G24).

6.2.5 Leadership

Leadership is the social mechanism for influencing the behavior of individuals to achieve a common goal (Scott and Davis 2007: 66). Effective leadership identifies the strategies and organizes the members' activities to achieve the goal of the organization. Disaster response is a highly dynamic process, and responders could not just follow standard operating procedures to solve problems. A respondent commented, "[o]ur performance depends on the leader's personal experiences and capacity… We do have the response plan, but the performance of our organization is heavily related to the leader's decision on setting priorities, coordinating resources, and identifying key tasks. Otherwise, we could just use a computer to lead us"

(Respondent G24). The attitude and decisions of a leader affects an organization's behavior towards building coordination and collaborative relationships. Therefore, depending on the attitude of leaders, leadership may promote or constrain interactions.

6.2.5.1 How Leadership Promoted Interaction

In the ChiChi Earthquake response system, where actions by formal institutions were limited, the quality of leadership was critical to identify the strategies, to set up the priority of response measures, and to allocate the resources and personnel for solving problems. The leaders can facilitate interactions through empowering the organizations to get involved in the response system. For example, after the ChiChi Earthquake occurred, former President Lee utilized his legal authority to order the military to fully engage in response activities. Therefore, the military could actively be involved in the response system and interact with the other organizations in the field without acting against the law.

Leaders also can promote interactions by breaking the legal limitations that exist in the system. One of respondents provided an example of a leader's influence on forming networks: "[r]ight after the Earthquake occurred, there were many professional search and rescue teams from foreign countries wanting to help. However, they could not enter our country without a valid visa. It was the commander's decision to give those people visa exemption"(Respondent G21).

A leader can also facilitate interactions by making a direct command. For example, after Typhoon Morakot, when the commander in the Central Emergency Operations Center assigned staff to coordinate supplies, he guided the staff to initiate interactions with the private sector by providing names of companies. "If he had not given me those names, I would not know who to contact," the respondent stated (Respondent G11).

6.2.5.2 How Leadership Constrained Interaction

One of respondents mentioned, "some command systems engage the staff to help the commander to make decisions. In our system, we rely highly on the commander's personal decisions. If the commander is an expert, then it won't be a problem. However, many of our commanders are politically appointed officials and are changed frequently. They usually are not professionals in disaster management either" (Respondent G15). Since leadership is the quality that is associated with an individual's judgments and attitudes, a leader's decision could have a negative influence on the communication and coordination activities in a system.

An example from the Typhoon Morakot event shows that a leader's attitude affects an organization's interactions with others. According to Respondent G17, "[t]he mayor of our town has a tough personality. He prefers to work with the local voluntary groups and doesn't like to follow the fire department's rules." In Chinese, the respondent described the mayor and the chief of the fire department as "a carriage drawn by two horses that are heading in different directions."

6.3 CONCLUSION

The analytical results of this chapter show that the formation of interorganizational networks under analysis were influenced by both the formal design of the response system, as well as factors related to interaction processes, which emerged and evolved during the response periods. These factors worked interdependently to influence the behavior of the organizations in the response systems.

In terms of the structure factors that influence the formation of interorganizational networks, the results showed that formal institutions and information and communication technology played a key role in guiding and promoting the communication and coordination activities of disaster responders. However, the formal structure also inhibited the organizational cognition process and delayed the distribution of information. Communication and coordination were constrained because information and communication technology, which are vulnerable to disruptive disasters, did not function as designed.

Beyond structure, the formation of interorganizational networks is also influenced by factors such as norms, culture, leadership, social connections and the adaption activities that emerged during the emergency response process. For example, the emergent norms of humanitarianism, effective leadership and pre-existing social relationships promoted interaction and communication among organizations. However, the norms of bureaucratic system, and the cultural barriers among organizations also worked to constrain interactions and coordination among emergency responders.

7.0 LEARNING AND POLICY CHANGE IN THE TAIWANESE DISASTER RESPONSE SYSTEM

The empirical data indicate that Taiwan's disaster response system changed as a result of the two studied events. However, the existence of change does not mean that the response system learned. In this study, a system is considered to have learned when it solves problems and improves its performance (Birkland 2006). This chapter aims to address two questions. First, to what extent did Taiwan's disaster response system learn after the two focusing events. Second, what were the factors, if any, which influenced the response system's capacity to learn.

Based on the criteria identifies for achieving this goal, I evaluate the performance of the system in the ChiChi Earthquake event, analyze the problems present in the system, and identify the changes made after the ChiChi Earthquake. Then, through analyzing the performance of the response system in the Typhoon Morakot event with the same set of criteria, I consider the extent to which the performance of the system improved. Finally, I analyze the factors that promoted and constrained learning within the response system.

7.1 SYSTEM GOALS AND KEY CRITERIA OF GOAL ACHIEVEMENT

This section identifies the goals of Taiwan's disaster response system during the studied events, as well as the challenges related to the achievement of these goals. Then, this study suggests that

the goals of the system are best achieved through the development of a resilient disaster response system in which the organizations act collectively with shared cognition. Based on this perspective, I proposed a set of criteria for building a resilient disaster response system.

7.1.1 System Goals and Challenges

According to Mileti (1999), disaster response refers to the "actions taken immediately before, during, and after a disaster occurs to save lives, minimize damage to property, and enhance the effectiveness of recovery" (p. 23). Based on the data collected from content analysis and semi-structured interviews, the major tasks carried out in Taiwan's disaster response system included: (1) before the disaster, to take the emergency measures to minimize lives and property losses, such as switching off gas to prevent fires in the case of earthquakes, or evacuating residents from the area under risks in the case of typhoons, (2) after the disaster, to perform search and rescue tasks to save lives, (3) to shelter and provide relief assistance to victims, such as food, clothes and medical care, (4) to restore lifeline systems and transportation infrastructures that were damaged by the disaster, bringing the system back to normal functions; and (5) to makes sure that the organizational actors in the system had the administrative support they needed to communicate, coordinate, and to manage resources and supplies. Table 37 shows the organizational functions and goals in Taiwan's disaster management system addressed by the interviewees.

Table 37 Summary of Organizational Functions Performed in Relation to Tasks in Taiwan's Disaster Response System

Functions	Tasks	Number of Response	Respondent ID*
Emergency Response	Evacuation	2	G2; G7
	Search and Rescue	8	G2; G4; G6; G13; G14; G21; N3; N8
	Confirm Clients and Resident Safety	4	N10; N12; N13; N14
	Emergency Medical Care	2	G16; N5
Disaster Relief	Sheltering	7	G9; G21; G23; G24; N1; N7; N10
	Provide Supplies	6	N1; N11; N12; N13; P1; P2
Administrative Operations	Coordinate Response Measures	4	G1; G8; G14; N7
	Collect and Reporting Information	6	G5; G11; G15; G23; G24; N5
	Mobilize and Manage Resources and Supplies	12	G7; G9; G11; G13; G14; G15; G22; G23; G24; N1; N6; N13
Restore and Recover	Restore Lifeline System: Roadways, Water, Gas, Telecommunication and Electricity Infrastructure	3	G3; G8; G14

* Refer to Appendix A for respondent's ID, organizational affiliation, and position.

Aside from performing routine tasks, the government faced the following challenges while responding to the disasters. First, large-scale disasters usually cause intensive and wide range damage that requires efforts that exceed the regular operational capacity of a system. As one of respondents stated, "[t]he challenge facing our organization was the lack of manpower. We didn't have enough people to close 18 bridges within 3 hours" (Respondent G3). Thus, the government needed to bring in external resources to solve the problem.

Second, the response required the actors in the system to take rapid action to save lives, to relieve suffering, and to resume normal operations of society. Any delay in disaster response activity would lead to even greater social and economic costs. A respondent recalled his experience in the ChiChi Earthquake event as "racing against time to save lives" (Respondent G18).

Third, the formal structure of the disaster response system was damaged and could not pursue its assigned function. Disaster response systems are often designed with the assumption

that each organization can perform its function with full capacity immediately after a disaster. However, the empirical data indicates that the formal structure was not resilient to the impact of disaster. For example, in the ChiChi Earthquake event, the disaster response system could not function as designed because many township governments had collapsed and could not perform their standard operating procedures. One report indicated the challenge, "the Earthquake destroyed our command system of the county and township governments. The police, fire, and civil service systems were all crashed" (Chou 2001: 199).

Fourth, disasters usually damage the communication and transportation infrastructures that responders rely upon to exchange information and to deliver services. It is difficult for the command system to place orders without having connected communication channels. The broken bridges and roadways also impeded responders from entering the impacted area and delivering goods and services. As one of the respondents indicated, "after the disaster occurred, you needed to restore the communication system in order to make the command system work…we also had to map out the commutable roadways, most of responders need this map to send the supplies in or evacuate victims out from the area" (Respondent G3).

Fifth, the government may have to operate with nonofficial responders. Disasters can generate a sizeable amount of damage, which not only requires the engagement of government agencies, but also evokes the actions of nonprofit and private organizations. The involvement of nongovernmental actors served to complement the government's limited capacity, since the cost would be extremely high for the government to be always equipped with full capacity for disaster events occur with low probability. These organizations, however, usually have different capacities, institutional backgrounds, and different decision making process. It is challenging to coordinate these organizations to achieve the common goal at the same pace.

These challenges show the uncertainties, dynamics and diversities that are present within a disaster response system. The bureaucratic structure, which is also vulnerable to disaster events, is not able to achieve the goals of a disaster response system alone. Instead of trying to create a perfect institutional structure to defend against potential risks with limited human knowledge, resilience is a more rational management approach (Comfort, Boin and Demchak 2010). Rooted in the discipline of engineering, biology and psychiatry, the concept of resilience refers to a system's capacity to recover or bounce back from disturbances. Rather than focusing on preventing the occurrence or resisting the disturbances, resilience emphasizes the system's capacity to resume normal functions after a disaster (de Bruijne, Boin, and van Eeten 2010).

7.1.2 Criteria of Goal Achieving

In the domain of disaster management, Comfort and her colleagues define resilience as the "capacity for collective action in the face of unexpected extreme events that shatter infrastructure and disrupt normal operating conditions" (Comfort et al., 2010:33). This definition emphasizes disaster management as a collective action that requires continuous interaction process among actors to exchange information and resources. Disaster response systems are dynamic interorganizational systems that consist of various organizations with different rules and operational functions. It is necessary to create a "common knowledge base" among actors to promote collective actions for achieving system goals effectively (Comfort et al. 2010: 35).

Derived from this prospective, shared cognition is central to the development of a resilient community that can successfully respond to disaster events (Comfort 2007). An effective disaster response system must possess the decision making processes needed to build shared cognition. First, the organizations in the system must have the capacity to detect the

potential risks in the region. Second, the organizations must recognize and interpret the risk, which will lead to informed action. Third, critical information is transmitted to other key actors to build the awareness needed to support collective action. Fourth, based on the cumulated risk information, organizations in the system are mobilized and organized to take informed, coherent collective action to respond to disturbances (Comfort et al. 2010).

The challenge of building a resilient disaster response system is to sustain the balance between structure and process. The tension between structure and process comes from the need to have both stability and flexibility in response operations. Formal structure provides stability and predictability. However, it is also important to maintain flexibility to enable organizations to adapt to the urgent demands of the environment. Based on the analytical results presented in Chapter six, the following sections discuss the characteristics of structure and process that promoted resilience in the disaster response systems under analysis.

7.1.2.1 Knowledge and Risk Awareness

Cognition is the activity of processing information, applying knowledge, and understanding a situation that requires action. It requires decision makers and emergency responders to be equipped with the knowledge needed to recognize risk. This essential knowledge includes the capacity to interpret and detect potential risks from incoming information, the vulnerability of the regions exposed to threats, and the stock of resources available in the social system that will respond to the potential disturbances. As one informant stated, "[t]he problem of responding to Typhoon Morakot was that we had never experienced a typhoon like it, which brought record breaking rainfall in a short time. We were not prepared for responding to an emergency situation like it" (Respondent G1).

This knowledge and risk awareness should not only be possessed by professional institutes, but should also be transmitted to the organizations and the communities that are exposed to the potential risks. The government's disaster preparedness and response measures would not be effective, if the policy targets did not recognize the necessity of those measures. For example, when Typhoon Morakot approached, some local governments started to evacuate the residents who lived in regions exposed to risk. However, some of residents rejected the evacuation because they did not consider the Typhoon a threat (Respondent G6).

7.1.2.2 Formal Institutions that Facilitate Interactions with Flexibility

Formal institutions played a role in reducing the transaction costs of interaction and facilitating interactions and communications. In the formal disaster response system, organizations are often divided and assigned specific professional functions. Professional divisions encourage organizations to focus on certain types of information, and to build the expertise needed to interpret and detect the potential risks from the gathered information.

The stability and predictability provided by institutions can lower the transaction costs of interactions and communications among actors. The findings show that organizations, when considered as individual entities, usually operate with rules and they pursue their legal functions (Respondents G1; G2; G3; G8; G10; G15; G16; G23; G24). The legal mandates can identify interorganizational interaction as one of the regular tasks of the organizations that operate in the system. When emergency situations occur, these organizations are programmed to interact and to transmit information to the organizations identified by formal institutions. During disaster response operations, the organizations with legal authority can also coordinate collective action and mobilize resources to solve certain problems.

Although the formal institutions can reduce transaction costs, they can also generate problems of rigidity (Respondents G3; G9; G14). Due to the uncertain nature of disasters, formal institutions may not be able to respond to urgent demands. A resilient system should be able to adapt its strategies to solve problems as the environment changes. Therefore, well-designed formal institutions should recognize the need of flexibility, and allow organizations to adapt to changing situations without violating laws.

7.1.2.3 Information and Communication Technology

ICT are critical for rapidly and accurately exchanging and sharing information among organizations interacting in a disaster response system, which help decision makers to take timely action. During disaster response operations, organizations have to process large amounts of information from formal and informal sources. However, these organizations have limited capacity to process incoming information, and the accuracy of information is critical for organizations that need to make informed decisions (Respondents G2; G7; G10; G15; G20; N1; N2;). Respondent G10 provides an example, "during Typhoon Morakot, we received fragmented pieces of information about the situations. People told us there were hundreds of victims trapped in the mountain area, but we could not verify this piece of information and we didn't know what exactly the situation was." Therefore, a disaster response system should apply information and communications technology to help them to effectively sort and filter incoming information.

This empirical study showed that when the disasters occurred, ICT infrastructures were usually damaged or broken, which impeded interaction and communication among organizations. In a resilient disaster response system, the design of the ICT system should take potential disruptions into consideration, thereby ensuring that communications will not be constrained by a disturbance. For example, a disaster response system may collect data from

multiple sources with various communication technologies (Respondent G7). When one of communication technologies fails, the system still can operate by using other technologies.

7.1.2.4 Capacity of Actors

While the formal structure, such as institutions and the design of ICT, frames the way that organizations interact and communicate with the others, the capacity of organizations to implement institutions and to utilize ICT also influences performance. It is critical that the organizations in the system possess the human resources, financial resources, and knowledge to pursue the organization's responsibilities in the disaster management system. Disaster response is also a self-organizing process in which each organization evolves and adapts to situations in the system. The capacity of each organization to pursue its professional functions, to build connections with other organizations, to transmit information, and to utilize available resources to solve problems, in sum, would improve the entire system's ability to respond to disasters.

The findings show that in both the ChiChi Earthquake and Typhoon Morakot events, local governments often failed to pursue their functions, either due to the disruption of the disaster events or due to a lack of professional capacity to perform their legal responsibilities (Respondents G1; G2; G10; G13; G14; G17). The local governments play an irreplaceable role in the collection of information and the delivering of services to local residents during emergency situations. The dysfunction of local governments often leads to the failure of command and control systems and affects the performance of the entire response system. As Respondent G13 stated, "we didn't have the knowledge to make decisions for towns and villages. They have to take the responsibility to decide when and where to evacuate to…If they didn't report to us, we have no way to know what happened in that small village."

7.1.2.5 Experienced Leaders

In disaster situations, organizations often operate without reliable information about the state of the response network. Nevertheless, leaders are expected to make decisions that guide organizational action (Respondents G1; G4; G5; G10; G13; G14; G15; G21; N10). The leader of an organization plays an important role in that they set the priorities, facilitate emerging nodes of coordination, organize external resources, and communicate response strategies to its members. An experienced leader with professional knowledge and experience can better diagnose the problem and effectively mobilize resources to solve problems.

While leadership is critical for all organizations in a disaster response system, Boin (2010) specifically discusses the system resilience from the perspective of public leadership. When a disaster or crisis occurs, public leaders are expected to coordinate response activities, provide explanations to the public, and restore social order. However, in practice, right after a disaster event occurs, local communities, first responders, and volunteers who lack formal leadership structures usually conduct response activities. Public leaders play a more significant role in the long run. In the short run, what the public leaders should do is to avoid certain pathologies that are often observed in a disaster response system (Boin 2010: 134). For example, the leaders should not wait for all the facts to emerge before making critical decisions, or act as if the command-and-control structure still stands, since the first responders need flexibility in local operations. The leaders should also avoid berating the public, and should build good communication relationships with the media (Boin 2010: 134-136).

7.1.2.6 Culture of Sharing

Even though interorganizational interaction can be facilitated through formal institutions, the findings indicate that the willingness to share played a significant role in shaping the interactions

of the organizations that operated in the field. Each organization inevitably met and interacted with multiple organizations from different backgrounds. These interactions may or may not be required by law. The invisible barriers among organizations with different institutional, political and ethnic backgrounds can constrain the transmission of information and inhibit mutual understanding among actors that are critical for building shared cognition in the network (Respondents G12; G13; G14; G22; N6; N11). This barrier could be broken when the culture of sharing is widely accepted and identified by the actors in the system.

7.1.2.7 Norms of Pursuing Common Interests

The norms of mutual support and altruism also facilitated the involvement of organizations in the response system. These voluntary behaviors brought resources, including money, supplies and manpower, into the system, which complemented the government's functions. This large number of organizations, each with different backgrounds and missions, entered the system to serve the victims. Sometimes there were more service providers than receivers (Respondent G23). Therefore, competitive relationships and politics started to emerge among the actors, which diminished the effectiveness of the interactions that occurred within the network. There are usually no regulations or market mechanisms that can manage the conditions within which disaster response systems must operate. Therefore, in addition to norms encouraging involvement, there is also a need for a norm that encourages organizations to commit to behaviors that enhance public interests, rather than be drawn into the competitive behaviors.

7.2 PERFORMANCE AND CHANGES OF THE DISASTER RESPONSE SYSTEM

This section evaluates the performance of Taiwan's disaster response system as it responded to the 1999 ChiChi Earthquake and 2009 Typhoon Morakot with the criteria developed based on the resilience perspective. This section also identifies the changes that made in the system after each event.

7.2.1 Performance of the 1999 ChiChi Earthquake Response System

Although Taiwan is exposed to the threat of earthquakes, when the ChiChi Earthquake occurred, the government was not prepared for such a large-scale disaster. Due to the low probability of the event, Taiwanese society also failed to take the potential risk as a serious concern. Prior to the Earthquake, even though the Central Weather Bureau had pointed out that Chelungpu Fault was likely to move, this information did not evoke sufficient awareness or actions to prepare for the threat (Respondent G22). It was the power of the earthquake and the wide spread electrical outages that enabled organizations, first responders, and government officials to sense and recognize the size of the event and the need to take timely action. The shared cognition among actors played the key role of activating nation wide response actions right after the Earthquake. Table 38 summarizes the performance of the ChiChi Earthquake response system.

When the government agencies became involved in response activities, their performance was constrained by the lack of formal institutions, disrupted ICTs, and limited response capacities. First, the operation of the response system during the ChiChi Earthquake event received minimum influences from the formal structures (Respondents G6; G21; G24). The lack of formal institutions made it difficult to communicate and coordinate among government

agencies. At the national level, each ministry proposed the response measures based on its regular function. These ministries did not effectively communicate or share resources. In practice, most policies and response activities were implemented by the fire departments. But due to its low hierarchical status, the Fire Agency did not have the authority to coordinate the response activities of the ministries (Lin et al. 2000: 52). Similar situations were also observed at the county level. Most disaster response related tasks were implemented by local fire departments, but the fire departments did not have the authority to coordinate other departments (Respondent G2).

Table 38 Summary of Performance Factors: 1999 ChiChi Earthquake Response System

Aspects	Factors	Number of Response	Respondent ID*
Structure Aspect	Lack of Formal Institutions to Follow	5	G4; G6; G14; G21; G24
	Disrupted Information and Communication Infrastructure	7	G6; G13; G18; G19; G21; G22; G24
	Lack of Capacity and Equipment	3	G13; G18; G19
Process Aspect	Active Public Leadership	6	G4; G6; G14; G18; G19; G24
	Emergent Norms of Humanitarianism and Voluntarism	8	N1; N6; N7; N8; N9; N11; N12; N14
	Self-organizing behavior	6	G6; G18; G19; G22; N7; N24
	Political Cleavage and Polarization Constrained Interactions	2	G14; G19 Academia Sinica 2001; Lin et al 2000

* Refer to Appendix A for respondent's ID, organizational affiliation, and position.

Second, the performance of the response system was also constrained by the dysfunction of ICT during operations. The ICT system was designed with the assumption that agencies at each jurisdiction level would be functioning normally during the emergency situation. The government at the national level could collect information or deliver commands through the hierarchical structure. In reality, the telecommunication and cellphone systems that the

administrative actors were supposed to rely on were damaged. In the field, only police and fire departments and military units had radio systems that worked. Without reliable means of communication, it was difficult for the national government to collect information from the local governments, to accurately allocate resources, and to dispatch manpower to regions in need.

Third, the emergency response operations performed after the ChiChi Earthquake were constrained by the limited capacities of the organizations involved. Although Taiwan's government was aware of the need to establish a disaster management system prior the earthquake, the government was implementing the policy with the principle of "not increasing budget and personnel quota" (Lin et al 2000: 45). Therefore, even though the government had established organizations for carrying out disaster management tasks, people worked in these organizations part-time, and did not have the professional skills and knowledge needed to respond to disasters. With insufficient investments in the disaster management system, administrative organizations were limited in their capacity to perform their formal functions, such as coordinating and supplying resources.

This insufficient investment in the disaster management system also constrained the performance of the first responders. As first responders, the fire fighters traditionally only receive fire training, but they were also expected to implement disaster response tasks. Unfortunately, the fire fighters did not have the professional skills and equipment needed to conduct search and rescue operations after the earthquake. This created additional problems. For example, as the fire departments had become devoted to search and rescue operations, they also had no spare manpower to serve as the staff in the decision making process in the emergency operation centers (Lin et al 2000: 53).

Although the formal structure in the disaster response system did not facilitate effective communication and coordination among organizations, it did allow the actors in the system to self-organize and adapt. While the role of formal structure was limited, the disaster response system that responded to the ChiChi Earthquake event operated according to a self-organizing process that was significantly influenced by the leadership, self-organizing behavior, and involvement of voluntary responders.

The public leaders at the national level showed high adaptability in the operation process. Right after the earthquake, the President and the Prime Minister held meetings with high-level officials and instructed the ministries, including the military, to carry out emergency response measures (Lin et al 2000). On the same day, the President addressed the nation and indicated that the government was taking action to help society recover. The national government recognized that the current legal structure did not help the system to take the appropriate response and recovery activities. Therefore, the President declared a state of emergency and established the 921 Earthquake Post-Disaster Recovery Commission (Lin et al 2000). These measures helped the government to restore the command-and-control system and gradually brought the system from chaos to a stable status (Respondents G4; G6; G14; G18; G19; G24).

The mayors and magistrates at the county level also quickly recognized the need for emergency response. Most of them used their legal authority to coordinate administrative resources, fire fighters and police to solve problems. Situated between the national government and the municipal governments, the county governments played a key role to collect and transmit information between the higher and lower level entities. The performance of county governments varied. The magistrates' relationship with the townships and the national governments influenced the quality of communication and coordination. For example, before the Earthquake, the

magistrate of Nantou County had been in political conflicts with the managers of various townships (Fu 2000). Therefore, during the emergency response process, the magistrate had difficulties interacting with, and coordinating, the townships (Respondent G19). As the magistrate also belonged to a different political party from the ruling party, he could not gain the support and trust he needed from the national government. These political factors placed the Nantou County Government in a difficult situation during the response (Peng 2001: 83-112).

The performance of the response system was largely complemented by self-organizing and voluntary engagements. As one interview respondent indicated, "to my observation, 70-80% of victims were rescued by their neighbors, or local voluntary responders, and only 10-15% of victims were rescued by the governmental rescue forces" (Respondent G6). Many local search and rescue teams and nonprofit organizations voluntarily provided rescue and relief assistance to the victims before the governmental responders arrived. When the government experienced a shortage of supplies, private companies and nonprofit organizations helped to collect the needed supplies from overseas. However, because there were so many organizations in the field, these voluntary behaviors also become problematic in that the government had to expend additional efforts to coordinate the collective action.

7.2.2 Lessons and Changes after the 1999 ChiChi Earthquake

The ChiChi Earthquake was a critical test for the capacity of Taiwan's disaster response system. It revealed the discrepancies between the existing policy and its performance in practice. The ChiChi Earthquake experience provided the following lessons. First, there was a need to establish a disaster management system throughout the whole administrative system, across all jurisdiction levels (Respondents G4; G6; N5). The National Emergency Plan, as an

administrative ordinance, did not possess the legal status necessary to promote systematic change. Taiwan needed a law that would clearly identify the responsibilities and obligations of governmental and non-governmental entities within the disaster management system.

Second, besides the establishment of a formal legal structure, there was also a need for capacity building within governmental organizations at all jurisdictional levels. The ChiChi Earthquake experience revealed that governmental agencies at the national, county and municipal levels lacked professional training, experience, and equipment (Respondents G6, G13, G19). This problem also relates to the fact that, without clearly defined legal responsibility, it was difficult for government agencies to attract and develop professionals.

Third, there was a need to improve communication and coordination by strengthening ICTs and the culture of sharing information among the administrative system, military and non-governmental actors (921EPRC 2006: 52). During the response of the ChiChi Earthquake, the actors in the system did not equip functional ICTs to exchange information or communicate. With insufficient information, decision makers could not effectively allocate resources, which delayed rescue operations and the provision of relief assistance (Respondents G6; G21). Even though both the military and administrative systems belong to the governmental system, their institutional backgrounds caused coordination difficulties. The response experiences also showed the critical role of non-governmental organizations in emergency situations. With appropriate management and coordination, non-governmental organizations may complement public sector activities.

Fourth, there was a need to build a knowledge base for disaster mitigation and prevention (Respondent G5). The ChiChi Earthquake showed that seismic and other types of potential disaster related knowledge are required to prevent and cope with the potential risks faced by

Taiwan. An investment in scientific research and advanced technology was critical to accumulate the necessary knowledge base.

As discussed in Chapter 4, Taiwan's government recognized the need to establish the formal legal structure of its disaster management system and passed the Disaster Protection and Prevention Act in 2000. Besides the passing of the Act, there were also substantial policy programs and changes that were carried out by the government and nonprofit organizations. This section does not discuss all of the changes that were made to the system, but only identifies the key changes that were related to the system's performance after Typhoon Morakot.

The passage of the Disaster Protection and Prevention Act in 2000 provided government agencies at all jurisdictional levels with the legitimacy and responsibility to develop their disaster management capacities. Because several ministries share disaster management functions, efforts to improve the response system were distributed across several ministries and agencies in government. Each ministry had its own focus and strategy. This section provides some examples to illustrate the changes made in the system.

The Ministry of Interior is responsible for the most frequent disaster events in Taiwan, including typhoon, earthquake, fire and explosion. After the ChiChi Earthquake, the Ministry of Interior implemented several policy changes through the National Fire Agency, one of the affiliated agencies of the Ministry of Interior, besides strengthening the building code. As a new agency, which received its independence from the National Police Agency in 1999, the National Fire Agency became the primary organization responsible for disaster management policy in Taiwan. This meant the National Fire Agency not only had to fulfill its responsibility as the national fire protection agency, it also had to fulfill its responsibility as the national disaster management agency. According to its annual policy plan, the National Fire Agency invested in

hardware, physical buildings, and training related to fire protection tasks. Although these programs did not directly relate to disaster response, the improvement of the fire protection system contributed to the agency's disaster response capacities.

Table 39 Summary of Tasks in Relation to Objectives in Policy Programs, National Fire Agency, Taiwan

Objectives	Tasks
Construct Fire Fighting Management System	Developing fire code
	Providing fire fighting training
	Implementing public fire safety education and examination
	Enhancing the capacity of fire investigation
	Purchasing fire fighting equipment and vehicle
	Constructing fire department facility
	Building voluntary fire fighting squad
	Build Fire Emergency Information Management System
Build Special Search and Rescue Squad	Enhancing the capacity in urban search and recue
Build Airborne Fire Fighting Squad	Purchasing aircraft, building facilities and providing professional training
Enhance the Capacity of Responding to Chemical Disasters	Purchasing vehicle and equipment, providing chemical disaster response training
Enhance the Quality and Capacity of Emergency Medical Services	Purchasing ambulance vehicles, provide trainings
Build Voluntary Search and Rescue Teams	Providing training and equipment
Build Emergency Communication System	Including the landline, radio, and satellite communication system
Enhance the Capacity in Disaster Prevention and Protection	Building the Emergency Operation Center facilities
	Building search and reuse training centers
	Developing disaster prevention and protection plans
	Assisting the cities and counties to develop disaster management plans
	Developing emergency management information system

Source: Annual Policy Plan Report from National Fire Agency (2001 to 2009)

The Soil and Water Conservation Bureau, Council of Agriculture is responsible for preventing landslides in the mountain areas. After the ChiChi Earthquake, the Bureau carried out a series of measures to manage the risk of landslides, which including adapting ecological engineering methods to construct facilities in the mountain area, reduce overdevelopment on hills via zoning policy, investigate and build the database of high risk landslide streams (SWCB 2002). The Bureau has actively utilized information and communication technology and

volunteers to enhance its risk management performance. For example, the Bureau adopted satellite remote sensing technology to monitor the change of landscape, and applied the dataset to GIS. The Bureau also recruited thousands of local people to serve as volunteers to monitor rainfall in local communities. Each volunteer would receive a simple device for measuring accumulated rainfall, and they report the rainfall volume information to the Bureau regularly. The Bureau monitors the rainfall through multiple information sources. When the accumulated rainfall reaches the alert value, the Bureau would issue warnings to the region exposed to the risk (SWCB 2012; Respondent G5).

The National Science and Technology Center for Disaster Reduction was established in 2003. According to the Disaster Prevention and Protection Act, the Center would serve as a technical advisor to the Executive Yuan on disaster prevention and reduction affairs. This Center also plays a critical role in research and the development of scientific technology that would improve disaster prevention and response decision making, assist the local government to strengthen their disaster response capacities, and to develop an information system that would integrate disaster information among ministries (NCDR 2012).

7.2.3 Performance of 2009 Typhoon Morakot Response System

The ChiChi Earthquake, as a focusing event, triggered a series of policy changes in Taiwan's disaster management system. These changes worked as the input to the disaster response system that operated during Typhoon Morakot. The following sections discuss the major factors that influenced the performance of the response system. Table 40 summarizes characteristics of the performance observed in the Typhoon Morakot response system.

Table 40 Summary of Performance Factors: 2009 Typhoon Morakot Response System

Factors	Number of Response	Respondent ID*
Lack of Risk Awareness	4	G1; G2; G3; N6
Guided by Formal Structure	12	G1, G2, G3; G8; G10; G11; G15; G16; G17; G20; G23; N1
Disrupted Information and Communication Infrastructure	8	G3; G7; G13; G15; G16; G17; G21; G22
Weak Local Government	8	G1; G2; G7; G10; G12; G13; G14; G17
Hierarchical Communication Structure Delayed Information Distribution	4	G1; G12; G14; G15
Constrained Role of Voluntary Search and Rescue Teams	3	G2; N3; N8
Active Engagement of Nonprofit Organizations	11	N1; N2; N4; N6; N7; N10; N11; N13; N11; N12; N14

* Refer to Appendix A for respondent's ID, organizational affiliation, and position.

7.2.3.1 Lack of Risk Awareness

As discussed in the previous section, the Soil and Water Conservation Bureau in Council of Agriculture built a database that included the location of the high-risk landslide areas, as well as landslide monitoring and reporting systems. When Typhoon Morakot approached, the Bureau issued warnings to the county and municipal governments that were located in the high-risk areas (SWCB 2009). However, due to their underestimation of the size of the storm, and their failure to recognize the risk posed to municipal managers and local residents, the local residents were not fully evacuated. This example shows the importance of risk cognition and awareness on triggering effective response actions. The national government possessed the knowledge to identify the potential risks and took the action to inform the entities in the regions that exposed to risks. However, each actor in a system may possess different levels of knowledge and risk awareness. The same information of risk situations were transmitted to the local townships, but

the local officials and residents failed to recognize the risk and didn't take the action to respond to the warning (Control Yuan 2009).

7.2.3.2 Operations were Guided by Formal Institutions

Compared to the ChiChi Earthquake response system, the Disaster Prevention and Protection Act played a significant role in guiding the governmental agencies to respond to the emergent situations caused by Typhoon Morakot. The national and county governments all launched the Emergency Operation Center as mandated (Central Emergency Operation Center 2009). Each ministry and department also positioned themselves in the Emergency Operations Center, as they have done several times during the previous few years (Respondents G1; G3; G5; G8; G15). However, when the continuous rainfall brought by Typhoon Morakot caused severe damage in southern Taiwan, and required the national government to engage in response operations, the Central Disaster Emergency Operations Center could not effectively communicate with the key actors in the system. In short, they were unable to bring the response system under control. For example, an informant who engaged in the decision making process in the Central Emergency Operations Center during the response to Typhoon Morakot described the situation: "[w]e couldn't get the full picture of the impacted area. We didn't have the information to deploy our resources…we tried to contact with the county governments, they also could not provide valid information…Without information, we could not propose an effective rescue plan either" (Respondent G10).

7.2.3.3 Disrupted Information and Communication Technology

Although most the governmental agencies at the national level followed the formal procedures, their performance was constrained by the dysfunction of the ICT. The operation of the Central

Disaster Emergency Operation Center heavily relied on information transmitted from the county and municipal governments. The failure of ICT, including satellite cellphones, EMIS, and the 119 Emergency Report System, made it extremely difficult for decision makers in the Center to take accurate and effective measures (Respondents G7; G10; G15). One respondent from the Center stated, "the most difficult challenge was to get information. We literally had no idea what was going on in the field. We knew something was wrong, but we just could not get any input to make decision" (Respondent G15).

When there is no incoming information, the central government should adapt to find out the situation with other methods. As stated by another respondent, "we cannot just sit and wait for information, or assume no news is good news. We have to use our imagination to think about the possible situations based on foundational knowledge and database, and dispatch our crew to investigate" (Respondent G10). Actually, they did. The Center sent out aircraft to take pictures of the impacted area. However, due to the cloud and the heavy rain, the pilots could not get pictures useful for decision making. The national government and county governments also demonstrated their adaptability by using information collected from social media to complement their decision making process. This showed that the national and county governments were willing to adjust the strategies to solve problems.

7.2.3.4 Local Governments as the Weak Link

Typhoon Morakot not only revealed the vulnerability of the formal structures and the ICT system in Taiwan's disaster response system during a large-scale disaster event, it also showed that the municipal governments were the weak link in the system (Respondents G1; G7; G8; G12; G17; G23). Compared to their performance in the ChiChi Earthquake event, although the national and county governments faced challenges and difficulties during the process, they were operating

with higher levels of professional knowledge. However, the municipal governments, as the first responders, were short on professional personnel and operational capacity (Control Yuan 2009). The weakness of the municipal governments came from two aspects. First, a certain amount of employees in the remote and rural townships usually did not live in the local communities. If an emergency occurred during the night or over the weekend, these employees would not be able to return to their office. These employees also tend to leave their position after three years, when their contract ends (Respondents G16; G17; G23). Second, the townships usually do not have sufficient budgets to hire full-time staff to implement disaster management related tasks (Respondents G13; G17). Under the budget and professional personnel constrains, townships were not able to effectively perform their functions and affect the overall performance of the response system during emergency situations.

7.2.3.5 Tensions between the Formal Structure and Self-Organization Process

Response operations following Typhoon Morakot showed the tension between the need for administrative control and the need for self-organizing processes in response to dynamic conditions. After the ChiChi Earthquake response, Taiwan's government focused on improving the performance of its disaster response system by focusing on its formal structure, including strengthening the legal structure, and investing in physical facilities and hardware. However, the government's emphasis on operating according to formal institutions drew several criticisms during the response to Typhoon Morakot.

First, the military were delayed in their response due to the lengthy procedures that had to be undertaken to request formal assistance (Respondents G1; G12; G14). During the emergency response to Typhoon Morakot, the county governments sought assistance from the military but they did not get a rapid response. When the military responded, it failed to provide the equipment

the county governments had requested. The interaction and communication process exchanged between the county governments and the military showed that, without familiarity and trust among actors, formal processes could become an impediment to the response system.

Second, the delayed military response encouraged criticisms about the quality of public leadership, including the President and the prime minister. Although they did not have legal functions in the response system, as public leaders, they made the mistake of "acting as if the command-and-control structure still operated," as Boin suggested. (2010:135). In the first three days, while the rainfall accumulated quickly in the southern Taiwan, the president, the prime minister and another high-level official were reported following their personal schedules. Although, according to the Act, the operation of the Central Disaster Emergency Operation Center did not require their engagement, the public leaders should not assume the response system would operate as formally designed. In fact, under emergency situations, most of the chain-and-command system did not function, and this required public leaders to use their authority to increase the flexibility and adaptability of the system. For example, the President could have provided the military with the flexibility it needed to react to requests from local governments. The president or prime minister could mobilize the resources beyond the formal system, such as contact with officials in the non-impacted counties to ask them to provide assistance to the impacted counties.

Third, the development of formal institutions may constrain the role of non-official responders. Compared to the ChiChi Earthquake, the voluntary search and rescue teams received more constraints from the government during the Typhoon Morakot event. From the government's perspective, the voluntary research and rescue teams should be managed and coordinated in the field. However, when the government applied the regulations, some voluntary

teams were not able to be legally involved in the response process. From the volunteers' perspective, they were acting to save lives and in the public interest, which should not be constrained by the government.

7.2.3.6 Active Engagement of Nonprofit Organizations

In terms of the interaction between the public and nonprofit organizations in the Morakot response system, the engagement of nonprofit organizations was as active as it was after the ChiChi Earthquake. There were still many small nonprofit organizations without emergency response professionals that temporarily participated in the system, and there were young students who were organized through the Internet to provide voluntary services.

In the Morakot response system, there were some large nonprofit organizations that had developed stronger professional capacities to provide emergency relief services. Similar to the trend observed in the government, nonprofit organizations such as Red Cross Taiwan, World Vision Taiwan, the Presbyterian Church in Taiwan, Tzuchi Foundation, and Dharma Drum Mountain Social Welfare and Charity Foundation developed formal structures to implement emergency response tasks (Respondents N1, N6, N11, N14). Meanwhile, some nonprofit organizations formed strategic alliances to share resources for responding to emergency situations (Respondents N1, N6, N7, N11, N14). For example, the Presbyterian Church, World Vision Taiwan, and Chinese Christian Relief Association formed an alliance to share information and resources when responding to emergency situations (Respondent N11).

Since nonprofit organizations were not formal emergency responders, according to the law, interactions between the government and nonprofit organizations were initiated through the social relationships that had been built during prior interactions (Respondents N2; N3; N4; N6; N7; N8; N12; N14). Although most of the nonprofit organizations' engagement was driven by

the norms of humanitarianism and altruism, competitive relationships were also observed among nonprofit organizations. As there were only a limited number of victims, the large number of nonprofit organizations had to compete to provide services (Respondents N7; G23). Especially, as these nonprofit organizations received funding from their donors, they needed to commit to carry out services to fulfill the donors' expectations.

Regarding competition, the nonprofit organizations with large client-bases had the comparative advantage to compete for the delivery of services. As there were many nonprofit organizations in the response system, victims would choose service providers based on their personal preferences. For example, Typhoon Morakot caused substantial damage to communities in the indigenous areas. A large number of indigenous people had close relationships with the Christian church and had already been receiving services from local churches. Therefore, when the disaster occurred, the Church could easily use the connections it already had with the victims and become the primary service provider in the region (Respondents G23, N6, N11).

7.2.4 Lessons and Changes after 2009 Typhoon Morakot

Typhoon Morakot was the most challenging disaster to occur in Taiwan since the ChiChi Earthquake. Typhoon Morakot can also be considered a test of the Taiwanese disaster management system. Typhoon Morakot revealed the following weaknesses in Taiwan's disaster management system.

First, there was the lack of risk cognition amongst those within the system. In this event, landslides in the mountain areas caused most of the deaths. Since there were visible and invisible costs to being displaced, unless the residents actually recognized the risk, they would not stop their daily lives or leave their property behind for the typhoon threat. The event showed that the

national government had cumulated the professional knowledge needed to detect potential risks. However, this knowledge and risk awareness was not transferred to the general public. The government's responsibility does not, however, stop at issuing warnings. To secure life and property, the government should also develop effective risk communication strategies and deliver sufficient information to the residents that live in vulnerable regions.

Second, there was the need to improve disaster preparation. A resilient system is not achieved by merely enhancing the capacity of government agencies. Typhoon Morakot showed there were limitations in the formal structures and the government's capacity. Under severe weather conditions, it was hard for external responders to rescue victims and to deliver supplies to the impacted areas. Each community should have had a shelter that stores sufficient food and supplies for local people, enabling them to be self-sustaining until external assistance arrives.

Third, there was a need for a resilient ICT system among governments at different jurisdictional levels. The experience of the Typhoon Morakot event showed that ICT disruptions impeded communication and coordination among governmental organizations across jurisdictional levels and prevented the national government from making accurate and timely decisions. Therefore, it is critical to build ICT systems that are resilient to large-scale disasters.

Fourth, municipal governments were the weak link in the disaster management system. The decision makers in the central and county governments had to rely on accurate and timely information provided by local officials to make decisions related to the allocation of resources and personnel. Although local officials are often the first to possess the regional knowledge needed to implement emergency response measures, this information was not passed along to the central government. Typhoon Morakot showed that municipal governments remained vulnerable to large-scale disasters, and that there is a need to enhance their disaster management capacity.

As Chapter four indicates, Taiwan's government revised the National Disaster Prevention and Protection Act to improve its disaster management system. The changes in laws included enhancing the legal authority of the National Fire Agency, assigning the military legal disaster response responsibility, and reinforcing the disaster management functions of county and municipal governments. Besides these institutional changes, there were also substantial changes in the implementation of disaster management policy.

First, the government emphasized evacuation efforts prior to the occurrence of a disaster. To avoid losses of life, the government adopted the strategy of evacuating people before the threat arrived. When the Central Weather Bureau issues a Typhoon Alert, the county and local government should now evacuate the residents that live in the regions exposed to the risks. As a respondent explained, "before the Typhoon Morakot event, we only focused on how to rescue victims. During Typhoon Morakot, we realized that we only had a limited capacity to respond to large-scale events and that it is also risky for the rescuers. Therefore, we shifted our focus to evacuation. The strategy was implemented in three typhoon events, and we have achieved the record of zero deaths" (Respondent G2). A similar strategy was also applied to the management of transportation safety. The highways, roads and bridges in high-risk areas will be closed when rainfall is expected to exceed the safety level (Respondent G3).

Second, several government agencies sought to improve their disaster management capacities by adopting new ICT. A variety of information and communication technology were adopted in the disaster management process after Typhoon Morakot. As shown in Table 41, these agencies actually adopted similar strategies and tools to monitor emergency situations and to communicate with the public. These agencies used the Google 2.0 geographic information system to present emergency situation information. When the agencies stationed in the Central

Disaster Emergency Operation Center transmit their information, it will be integrated and presented on the National Geographic Information System (NGIS) for decision making purposes (Respondent G7).

Table 41 Use of Applied Information and Communication Technology after 2009 Typhoon Morakot by Agencies

Agency	Ministry	Function	Applied Information and Communication Technology					
			GIS[1]	QPESUMS[2]	CCTV[3]	SMS[4]	Radio Broadcast[6]	App
Directorate General of Highways	Ministry of Transpiration & Communication	Roadways and bridges	✓	✓	✓	✓[5]	✓	
Soil and Water Conservation Bureau	Council of Agriculture	Landslides	✓	✓	✓	✓		✓[7]
Water Resources Agency	Ministry of Economic Affairs	Rivers	✓	✓	✓	✓		✓[8]

1: Google 2.0 System for decision making purpose
2: Quantitative Precipitation Estimation and Segregation Using Multiple Sensors for monitoring weather conditions
3: Closed-circuit television for monitoring the real time environment images
4: Short Message Service for distributing alerts to subscribed cellphone users
5: Location Based Service that submitted short messages to the cellphone users in a certain area
6: Broadcasting transportation information through the radio channel
7: The smartphone application that allows user to check real time rainfall, map of landslides, and lead the user to the closest shelter through GPS.
8. The smartphone application that allows user to check real time rainfall, flooding, and river water levels.

These organizations also extract weather information from the Central Weather Bureau, established the accumulated rainfall standards, and installed closed-circuit television (CCTV) to monitor high-risk areas. When the accumulated rainfall reaches certain levels, the agencies send messages through the short message service (SMS) to inform cellphone users who subscribe to the service. The Soil and Water Conservation Bureau and the Water Resource Agency also developed the application for the smartphone users to download. The smartphone application allowed the users to check real-time rainfall information, water levels, or lead the users to the closest shelter so that they can avoid potential landslides (Respondents G3, G5, G8).

The National Fire Agency recognized that each agency was developing its own information and communication systems, which actually served the same purpose: to deliver information to the public. However, the current approach may not be effective or efficient. For example, the content of the information often overlapped and the agencies could only reach a limited audience. After Typhoon Morakot, the National Fire Agency began to develop a public disaster information platform with computing technology that could integrate information from multiple sources, and then distribute that information to the public through television, radio broadcast, cellphone, fax, and even through convenience stores (Respondent G10).

Third, after Typhoon Morakot, the National Fire Agency continued to invest in physical infrastructure and equipment. For example, the Agency started to build two emergency operation centers in central and southern Taiwan that would serve as backup facilities for the Central Disaster Emergency Operation Center, which is located in Taipei. The Agency also invested in equipping mountain villages and indigenous communities with fire fighting tools and supplies, and held self-help disaster prevention training sessions (National Fire Agency 2011; 2012). To prevent the 119 emergency report system from breaking down due to the overloading of incoming phone calls from the public, the National Fire Agency launched the 1991 safety reporting system. This system allows the public to leave voice messages or to listen to messages left by family and friends. The public can also check the safety of their family and friends by dialing 1991 instead of calling 119 to occupy the system capacity.

Fourth, the government started to engage nonprofit organizations and private companies in the disaster management system. After Typhoon Morakot, the national government started to invite major nonprofit organizations to participate in disaster scenario simulation practices (Respondents N12, N14). The Disaster Management Office also worked with the 7-Eleven

convenience stores to collect real-time disaster situation data. In Taiwan, 7-Eleven is extremely popular, and has a store density of 1 store per 8.5 km^2. Given the advantage of its high density and 24/7 services, the Disaster Management Office works with 7-Eleven to collect the local real-time disaster situation information from the 4,820 stores that are locate all over the island. When there is an emergency situation, the government can also broadcast messages to the local residents through the stores' electronic display system (Respondent G15).

7.3 FACTORS THAT PROMOTED OR INHIBITED SYSTEM LEARNING

The performance of the response activities and the policy changes indicate that the two response systems adapted. Although there might be different opinions about how to improve the system or to solve problems, most participants in the system want to address the problems revealed by the focusing events. It is clear that attempts to solve problems encountered after the disaster events actually promoted learning within the system. There are several factors that facilitated or constrained the ability of the actors to contribute to the improvement of the system. Table 42 summarizes the factors that promoted and inhibited change and learning of the system. These points are discussed in further detail in the sections below.

Table 42 Summary of Factors that Promoted and Inhibited Change and Learning in Disaster Management in Taiwan, 1999 - 2009

	Factors	Number of Response	Respondent ID
Factors that Promoted Change and Learning	Focus Events as a Trigger Promote Change	8	G1; G9; G13; G15; G19; N1; N6; N13
	Learning from Experience	11	G1; G2; G20; G22; G10; G13; G23; G15; N6; N10; N13; P2
	Individuals Learn from experience	4	G1; G15; G23; G24
Factors that Inhibited Change and Learning	Lack of Resources	2	G13; G19
	Difficult to Transfer Individual Experiences to Organizational Knowledge	2	G14; G15
	Path Dependence	3	G6; G10; G21

* Refer to Appendix A for respondent's ID, organizational affiliation, and position.

7.3.1 Factors that Promoted System Learning

7.3.1.1 Focusing Events as a Trigger

As discussed in the literature review, focusing events draw the attention of the media and the public (Birkland 1997; 2006). Although mass media do not usually propose concrete policy solutions, the intense reporting can arouse discussion among the public, and increase pressure on the government to take action. The analytical results from the two studied cases show that Taiwan's disaster management system changed after the two focusing events. Several respondents recognized the changes in not just the formal institutions, but also in the daily practices of the government. For example, a respondent mentioned, "[y]ou can significantly feel the difference between before and after Typhoon Morakot. Now, they test the radio devices once a month and you can see many shelter facility constructions going on at local levels" (Respondent G17).

The changes that occur in a system are not always observed after a special event. It is the events that are intensively reported by the mass media and discussed by the public in the period of time after the event that helps to trigger system changes. As a respondent stated, "[a]fter the ChiChi Earthquake, there were several typhoons that caused lives and property losses in Taiwan. However, none of them drew as much attention as Typhoon Morakot. To be honest, Typhoon Morakot was not that devastating. It was the incident happened in Hsiaolin Village that made Typhoon Morakot significant, and so we saw those special efforts made by the government" (Respondent N7).

These focusing events did not only facilitate policy learning in the public sector, the ChiChi Earthquake also triggered the changes in the nonprofit sector. At that time, many nonprofit organizations in Taiwan did not have disaster response experience. After the ChiChi Earthquake, some organizations started to consider the need to expand their capacity to undertake disaster response tasks. For example, Taiwan Red Cross did not have the human resources or the capacity to implement emergency response and disaster relief tasks. As the respondent from the Taiwan Red Cross indicated, "during the ChiChi Earthquake, we didn't have the capacity to operate in the emergency response tasks. We received the financial and human resources assistance from the Japan Red Cross. It was after the ChiChi Earthquake that we saw the need to enhance our role in the disaster response system, and started to invest in hardware and professional training" (Respondent N1). Some religious and social welfare service organizations also provided emergency assistance to the minorities who were in need before the ChiChi Earthquake. After the earthquake, some of these organizations started to provide emergency relief assistance training to their members, and some of them started to expand their service capacity to accommodate potential needs (Respondents N1, N14).

7.3.1.2 Learning through Experience

The ChiChi Earthquake, as a focusing event, promoted institutional change in the system, and facilitated communication and coordination among key organizations through the building of the emergency operations center and its related task forces. It took time for these organizations to learn and become familiar with the operational and communication process in the system. Such policy change is an accumulated process. Each disaster event can bring new knowledge to organizations. Organizations learn how to interact and communicate with other organizations through the experiences acquired during each event. A respondent who participated in the operation of the Central Disaster Emergency Operations Center provides an example: "in the first few years after the National Disaster Prevention and Protection Act issued, the personnel who came to the meeting from each agency were often low-ranking employees. They could not make decisions and always needed to go back to ask their supervisor. Now, each agency would send the high-ranking officials to participate the meeting…. Since this institution has run several years, we almost can anticipate who will come to the meeting" (Respondent G15).

Between the ChiChi Earthquake and Typhoon Morakot, there were several typhoons that also caused damage to local communities. One respondent mentioned this point, noting that: "flooding is not news here, we have several years experiences of dealing with floods after typhoons" (Respondent G23). Taiwan's annual recurrence of typhoons has provided the organizations with an opportunity to learn and practice emergency response operations. As a respondent indicated, "we launch the Emergency Operations Center multiple times in every year, so we are familiar with the process and can react rapidly" (Respondent G21). The organizations in the response system not only learn from the domestic experiences, they also learn and

accumulate experiences by responding to the emergency situations that occurred in foreign countries (Respondents N1, G21).

7.3.1.3 Individual Learning

A substantial amount of disaster response knowledge is embedded in individual experiences. The individuals who participated in disaster events possess the knowledge learned in the field. Disasters events are rare. Most people may receive training in the normal times, or for small incidents, but not everyone has the experience of responding to large-scale disasters. Some challenges and unique issues are only observed in large-scale disasters. The individuals who participated in disaster response operations got the chance to learn by participating in the response process. As one respondent stated, "[t]hrough the experience of responding to the ChiChi Earthquake, we have a group of people who have more knowledge about how to deal with emergency situations. Their experience may not necessary transformed to formal institutions, but these experiences are embedded in their personal knowledge system. As long as they are still in our organization, we will benefit from their knowledge" (Respondent G1).

These experiences can enhance an individual's capacity to make judgments that enhance the performance of the organization after a disaster. A respondent who experienced the ChiChi Earthquake response indicated that those experiences helped him during the response to Typhoon Morakot, "with the experience, I knew which task has a higher priority, and how to design the work flows to enhance effectiveness. Even though there was the SOP to follow, the practical experiences make it goes smoother" (Respondent G24).

Individual knowledge also helped organizations to improve their disaster management plans and standard operating procedures. As Respondent G1 indicated, "when I got promoted to the high position in the government and had the capacity to influence the institutions, those

experiences helped me to identify the key issues in the system more accurately and enabled me to construct a disaster management system with better knowledge" (Respondent G1).

7.3.2 Factors that Inhibited System Learning

Even though the organizations attempted to learn, decision makers did not always make decisions that improved the performance of the response system. A system may fail to learn for three reasons. One is that the system does not have the knowledge needed to improve system performance. Second, the knowledge needed to improve system performance exists, but decision makers are constrained by political or other factors from making the right decision. Third, policy effectiveness was undermined during the implementation process. This section discusses the factors that inhibit the Taiwan's disaster management system from learning.

7.3.2.1 Path Dependence

Taiwan's disaster management system adopts the single hazard approach, which makes it difficult to share information and coordinate disaster management measures across functional departments. Within the current design, disaster management responsibilities and tasks are divided and shared by multiple ministries. The problem with this design is that it is often difficult for the system to develop effective disaster management policies, since each ministry tends to focus on its own function and to develop individual plans that lack of coherency with the plans developed by other ministries. As the findings in the research indicate, each ministry develops its own information system. A decision maker in the Emergency Operations Center has to work with several agencies to get a whole picture of the disaster situations (Respondents G3; G10).

Some informants mentioned the need to adopt an all-hazard approach to coordinate disaster management policy in Taiwan (Respondents G6; G10; G21). To reduce the potential risk of natural hazards in the future, Taiwan's disaster management system needs a powerful authority to develop and implement disaster mitigation policies, which include comprehensive land zoning plans and natural conservation plans (Respondents G5; G12). However, it is difficult for Taiwan's disaster management system to shift from the single-hazard approach to the all-hazard approach. The theory of path dependence may be applied to explain the difficulty of reorganizing the formal structure of disaster management system. Adopting the all-hazard approach requires the government to establish a new national agency that possesses the legal status and authority to direct the current ministries.

After responding to the ChiChi Earthquake and Typhoon Morakot, Taiwan's government recognizes that it needs a powerful authority to coordinate and integrate disaster management policies. Instead of adapting the all-hazard approach, the government adopted a strategy with higher political and administrative feasibility, which is to establish the Disaster Management Office as a staff agency of the Executive Yuan to coordinate disaster management policy.

7.3.2.2 Limited Investment in the Domain

Taiwan's government recognized that it needed to improve its disaster management system, and the passage of the Disaster Prevention and Protection Act was a significant step towards this goal. However, government at each jurisdiction level had different capacities to pursue this goal. While the national government has a larger budget and higher quality human resources to implement and develop the policies, the county and municipal governments are relatively tight in budget and personnel. Especially, for the townships, disaster management tasks are usually not the priority. The lack of resources leads to the problem of formalism in the policy

implementation process. Even though each government agency is organized to meet regularly and to develop the disaster management plans on paper, in practice, the conclusions made in the meeting and the developed plans are not implemented (Respondent G9).

The unevenly distributed resources also inhibit the government's capacity to improve the performance of the system as a whole. The disaster management system requires collective efforts among actors. One weak actor, who failed to perform its function, could undermine the effectiveness of information and resources flow in the disaster response system.

7.3.2.3 Difficulty of Transmitting Personal Experiences to Organizational Knowledge

Experienced personnel are assets for a disaster response system that can facilitate learning and improvement of the organizations. However, the system can only gain the maximum benefit from experienced personnel when these individuals are working for the organizations that are within the system. Although personal experiences can contribute to organizational learning, for example though writing reports, there are forms of tacit knowledge that are difficult to be transferred to others. A respondent stated, "disaster response is a type of internalized knowledge that is hard to transform to a written document, sometimes, it is just a inexpressible intuition. Just like that mastering Sun-Zi's the *Art of War* would not make a soldier become a general, eventually, he needs to learn from the experiences in the battle field" (Respondent G15).

The respondent further pointed out "the lack of a sense of belonging" among professionals as the deeper problem of organizational learning in the Taiwan's disaster management system:

> "I think in the disaster management field, people need to learn from experiences. But in our society, from the low-ranking firefighters to the high-ranking governmental officials, all work under negative pressures. When we didn't meet the expectation, the Congress and the mass media are extremely critical of us. Therefore, we can only be conservative, and passively avoid making mistakes,

> rather than being creative in solving problems. Lots of professionals in this field seek to escape. They tend to transfer to a different position or retire as early as they can. The retired professionals are treasured, because there is so much we can learn from them. But as I know, these people would never want to come back again. This country is too harsh on the emergency responders" (Respondent G15).

This quote indicates that Taiwan's disaster management system failed to encourage individuals with expertise to utilize their knowledge and capacity to improve the performance of the system. The respondent also echoes to the comment of another respondent, who indicated that it is the irrationality of the society and the vicious competition between political parties that leads to a conservative administrative system that hesitates to adapt and be creative (Respondent G14).

7.4 CONCLUSION

The response practices observed after these disaster events show that the response systems achieved similar goals, which was to overcome uncertain situations, stop the further damage, and help the victims to resume normal lives. Given the high uncertainty created by disaster events, it is infeasible to develop a disaster management system that can avoid all disaster damage. This study suggests that resilience is a more preferable goal for a disaster management system. The goal of a disaster response system should be achieved through building a resilient disaster response system in which the organizations act collectively with shared cognition.

The analytical results show that Taiwan's disaster response system faced the tension between the need of formalized structure and the need for flexibility and adaptability in the operation process. Based upon the lessons learned from the ChiChi Earthquake experience, the responders' response to Typhoon Morakot was guided by formal institutions. However, the

formal structure remained vulnerable to disruptive disasters. The study also showed that the organizations in the system learned and adapted at different paces. The national government and county government in the system possessed more resources to build their emergency response capacity. However, the capacity of the government at the municipal level was not improved at the same rate as the national and county governments. When a municipal government failed to perform its function, the performance of the whole system was undermined.

Policy learning is a cumulative process. Although the ChiChi Earthquake triggered substantial changes and adaption in the system, it was the experience accumulated from several events that allowed organizations to test and improve the operational process. In the learning process, experienced professionals are the assets of organizations, which can use their knowledge to improve the design of formal structure. The government also should overcome the political pressure, enhance the capacity of municipal government and encourage the professionals to utilize their experiences and knowledge to enhance the organizational learning process.

8.0 FINDINGS AND IMPLICATIONS

This study adopts the network governance and complexity adaptive system perspectives to analyze the operation of two disaster response systems and suggests that disaster response is a collective activity that can solve highly dynamic and complex problems. Promoting successful response to the consequences of disaster events, however, will require a governance strategy that moves beyond the traditional hierarchical approach. This chapter reviews the major findings of the study, proposes a set of policy recommendations, and suggests future research directions for improving the capacity of disaster management systems.

8.1 MAJOR RESEARCH FINDINGS

8.1.1 Composition and Evolution of Disaster Response Networks

A disaster response system is a network that consists of organizational actors from jurisdictions and sectors beyond those identified in the formal disaster management plans. This study identified 1,162 organizations in the core response system that formed after the ChiChi Earthquake and 685 organizations involved in the response to Typhoon Morakot. These actors varied in their institutional backgrounds and exchanged information and resources across

jurisdictional and sectoral boundaries. They performed a variety of tasks, including search and rescue, disaster relief, damage assessment, reconstruction and recovery activities.

Both response systems grew, as the situations unfolded and organizational actors became involved in disaster response activities. The analysis demonstrated that the organizations in the two events reacted and joined the disaster response systems at different rates. Where 80% of organizations that responded to the ChiChi Earthquake event entered the system within 8 days, it took the Typhoon Morakot response system 13 days to reach the same organizational capacity. This difference indicates that the organizations in the two response systems possessed different capacities to assess risk and to take action.

The structure of the disaster response networks also evolved, for example, when organizations in the systems interacted to exchange information or resources during the problem solving process. I analyzed the evolution of the network structures with three measures: density, diameter, and number of components. The results showed a trend of increased density, decreased diameters, and decreased number of components during the three-week period after the disasters. These results also indicate that both disaster response systems developed to become integrated networks, meaning that the organizational actors became increasingly connected.

8.1.2 Structure and Process Factors in the Network Formation

Through the literature review, semi-structured interviews with key informants, and reviews of official documents, I explored the factors that influence organizational behavior with respect to the formation of networks in emergency situations. I identified a set of factors related to the formal structures and the processes that facilitate and constrain organizational interactions in two disaster response systems. The structural factors included formal institutions, the attributes of

actors as defined by the formal institutions, and the design of the system's ICT infrastructure. The factors that emerged in the processes are norms, culture, uses of ICT, social relationships, and leadership.

8.1.2.1 Structural Factors

Structural factors represent relatively stable and permanent patterns of relationships in a social system. Organizations that operate in a disaster response system, especially government agencies, tend to follow formal institutions, fulfill their legal responsibilities, and exchange information through pre-existing communication channels. Therefore, a disaster response system's formal structure affects with whom, when, and how the organizations in the system will interact with each other. With an appropriate design, formal structures can promote the formation of networks by requiring certain actors to interact with others, by requiring actors to communicate and exchange information with others via specific ICT devices, and by conferring upon key organizations the authority to coordinate collective action.

Formal structures can also constrain the formation of networks in emergency situations. First, during the Typhoon Morakot event, the rigidity of institutions inhibited the organizational cognitive processes used to perceive potential risks. Second, according to the respondents from both cases, the hierarchical communication structure delayed the transmission of information among participating organizations. Third, functional divisions in the system created barriers among organizations, which increased the coordination and communication cost in solving the common problems. Fourth, a system that relies heavily on formal structure may fail to operate when the institution does not fit the need created by the emergency situation, or when the designed ICT is disrupted by disasters. These situations are common in disaster response contexts.

8.1.2.2 Process Factors

The formation of networks is also influenced by process factors that emerge during disaster response operations. The two studied events demonstrate that the pre-existing formal structures were not sufficient to support operations, and the organizations adapted and responded to changing situations by interacting with each other. The process factors may have encouraged interaction and communication in the response system, thereby promoting the formation of the response networks. For example, the norm of altruism and humanitarianism, the culture of "seeking help," pre-existing social relationships, and active leadership are factors that promoted interaction and communication in the disaster response systems under analysis.

The process factors of norms, culture, and leadership, however, may also impede the formation of effective response networks. For example, the norm of bureaucracy can limit the capacity of governmental agencies to initiate interactions or to build effective communication relationships. The cultural differences among organizations, the culture of political cleavage in Taiwan's society, and the lack of professional leadership may also prevent organizations from communicating and coordinating. During operations, interactions and communications may be constrained by the dysfunction of ICT due to the disruptions and the lack of human resources.

8.1.3 System Performance and Policy Learning

After both disasters, Taiwan's response systems saved lives, provided relief assistance and restored lifeline infrastructures to bring the systems back to normal functions. While performing these tasks, the system faced the challenges created by a dynamic, complex, and uncertain situation, and a disrupted chain-and-command system. I analyzed the performance of Taiwan's disaster response system using criteria derived from the concept of resilience, which refers to the

system's capacity to distribute shared cognition in the system and to sustain the balance between structure and process in operations. Formal structure is required for providing stability to the system. At the same time, a disaster response system must retain its flexibility and adapt to the urgent demands of the changing environment.

The findings demonstrated that the ChiChi Earthquake response system was not driven by formal structure, but rather, by self-organizing processes shaped by norms, culture, social relationships, and leadership. The performance of Taiwan's disaster response system after the ChiChi Earthquake was constrained by the lack of formal institutions, disrupted ICT infrastructure, and limited professional response capacities. However, the actors in the system showed high adaptability in the problem solving process. The leadership of public leaders, self-organizing behavior of the participants, and voluntary contributions encouraged by the norms of altruism and humanitarianism promoted the performance of the ChiChi response system.

After the ChiChi Earthquake, Taiwan's government focused on improving the disaster response system by strengthening its formal structures, as this was viewed as the main problem in the system. When Typhoon Morakot occurred in 2009, the response system showed improvement in that the formal structure actually guided the operation of the disaster response system. However, in practice, Typhoon Morakot revealed those who designed the new response system had overlooked the process factors. This means that, even with the updates, Taiwan's response system could not be classified as resilient. First, the formal structure inhibited the capacity of organizations to recognize potential risks, and prevented the government from taking timely measures. The performance of the formal disaster response system relied heavily on functional ICT. Although most the governmental agencies at the national level followed the formal procedures, these agencies did not have the information they needed to take effective

action due to the dysfunction of ICT. Second, organizations at the municipal level did not have the capacity to perform their functions. The municipal governments, as the first responders, played a critical role in collecting and reporting information to the higher authorities. However, due to the lack of financial and human resources, they were short on professional personnel and capacity to utilize ICT to report information and to carry out their formal functions.

Third, the system failed to recognize that culture diversity and political barriers would constrain interactions among organizations. Formal disaster management institutions represent generalized rules that do not take heterogeneity among actors in the system into consideration. Cultural barriers constrained the government's capacity to communicate with indigenous communities during the emergency situation. Communication and coordination were also constrained by the lack of informal social connections among the actors that belonged to different political positions. Fourth, high-level officials failed to use the leadership skills needed to mobilize external resources during the emergency situation. Immediately after the Typhoon made landfall, public leaders assumed that the formal system would function as designed. Consequently, public leaders failed to use their authority to facilitate organizational interaction and coordination in the response system.

The findings also indicate that Taiwan's disaster response systems attempted to learn and change. However, in the learning process, the system failed to recognize the importance of sustaining performance through the use of a resilient design. Changes within the system were triggered by focusing events, motivated by political pressure, and accumulated through experience. The system's capacity to learn was constrained by path dependency, the lack of investment in the domain, and the ineffective use of individual professional knowledge possessed by organizations.

8.2 POLICY RECOMMENDATIONS

The findings indicate that the central government has been the primary actor in Taiwan's disaster management system. The findings also indicate that, after the ChiChi Earthquake, Taiwan's government strengthened its formal disaster management institutions. Although the formal structure of the disaster management system has been improved, this study revealed the limitations of a government-dominated system that emphasizes the formal approach to disaster management. Rather, as the study results indicate, an effective disaster management system depends on the system's capacity and flexibility to adapt when formal structures do not fit emergency response needs. Thus, to better prepare for future disaster events, Taiwan should move beyond a system that is dominated by the central government. To this end, policy makers in Taiwan should take action to include local governments, citizens, as well as, non-profit and private organizations in the disaster management system.

To build a disaster resilient system, I propose the following strategies. First, shared cognition and responsibility should be promoted throughout the actors in the system, including the government and the citizens. Policy makers can do this by building local knowledge, and improving the quality of risk communication between the government and the general public. Second, the capacity of municipal governments and local communities should be strengthened through financial and human resources support from the national government, and the development of localized disaster management strategies. Third, the system should make investments to enhance the functions and utilization of ICT that are essential for information exchange and decision making. Fourth, cross-boundary cooperative relationships should be encouraged throughout the system. These cross-boundary relationships would ensure that both the nonprofit sector and the private sector are active in disaster management activities. The

cross-boundary relationships would also facilitate regional mutual assistance agreements and activities between county governments. The details of each of these strategies are discussed in the following subsections.

8.2.1 Enhance Shared Cognition and Risk Awareness throughout the System

There is a need to enhance risk awareness throughout Taiwan's disaster management system. As the system becomes more formalized, a clearly identified standard operating procedure will emerge to guide government agencies and their responses to potential risks. Although formal rules can ensure that responders can effectively react to certain emergency situations, they may also inhibit the capacity of the actors to detect and recognize potential risks that were not listed on written documents. As one respondent indicated, "now everyone reacts according to the Weather Alert, but what if there is an emergency without the Alert" (Respondent G3). Risk detection and recognition should be an ongoing process, rather than a passive reaction to formal rules. To enhance risk awareness, government agencies should equip themselves with knowledge about available resources, response capacities and regional vulnerabilities. When a potential risk is identified, organizations will be able to utilize this knowledge to make judgments accordingly.

Efforts are also needed to increase risk awareness among the general public. After Typhoon Morakot, the government's strategy to reduce the risk was to evacuate residents in at-risk communities whenever a typhoon warning was issued. Although this can directly reduce the number of deaths and injuries, there are the downsides to this strategy. First, this strategy places a huge cost on local governments and is not sustainable. In each evacuation, local governments must work with police and fire departments to conduct the evacuation and direct the evacuees to a shelter. It costs significant time and energy for local governments to implement this policy, and

it is not sustainable over the long run. Second, this strategy is only valid for disasters that are predicable. If there is an earthquake, or other unexpected emergency situation, this strategy will not help governments to function or to reduce risk.

Instead of passively forcing residents to avoid risk, governments should actively enhance the public's awareness and perception of potential risk. Once they become aware of potential risks, individuals would be able to take action to secure their property with minimum efforts from the government. Risk awareness could also be built through public education. For example, the government could communicate the potential risks and impacts of extreme events to the public. This communication process should not be done by simply playing slogan on TV programs or by distributing information flyers. Rather, the communication should target specific groups and deliver customized messages that directly relate to the audience's life experiences and their surrounding environments. The government can also enhance risk awareness by engaging the public in simulations and mock events. Although local communities face different disaster threats, the government does not currently include citizens in disaster simulations and mock events (Respondent G21). By increasing participation, the public will have stronger perceptions about the potential impact of disaster events, and can take appropriate action when emergency situations arise.

8.2.2 Build the Capacity of Municipal Government and Local Communities

Taiwan's national and county governments have significantly improved their disaster management roles and functions. The findings also indicate that municipal governments remain the weak link in the chain of command structure. This is an important finding because municipal governments, and the role of local communities in rural areas, are irreplaceable in the disaster

response system. Given the dependence of hazards upon geographical location, emergency response is highly localized. In such situations, it is often difficult for the national government to take the lead role, as it is not familiar with the contexts of the local environment.

Therefore, it is critical to strengthen the resilience of municipal governments, which will enhance the performance of the entire disaster response system. Although the government required municipal governments to establish Disaster Prevention and Protection Councils to carry out disaster management tasks after the Typhoon Morakot, we cannot assume that the capacity of municipal governments has been improved. Only when municipal governments direct resources towards their disaster management tasks and enhance the professional capacity of their personnel, will their capacity to respond to disaster events increase.

These capacity building efforts should also extend to local communities, especially those in remote areas. In some rural areas, a municipal government could cover regions that contain small scattered communities. In a disaster situation, external resources will not be immediately delivered to all small communities. Therefore, in rural communities it is important to secure the essential resources, and establish shelter spaces and means of communication prior to a disaster event. Once a community experiences a disaster, they must be able to use communication devices to send out information and to request assistance. The community must also have enough food and supplies to last until external support arrives. Finally, the government should engage local residents in the planning process. In doing so, governments would be able to utilize local knowledge to design and implement disaster preparation and emergency response plans that fit the needs and lifestyles of those that live within local communities.

8.2.3 Develop the ICT for Information Sharing across Functions and Jurisdictions

After Typhoon Morakot, ministries in the national government began to develop their own ICT systems to collect and exchange data and to communicate with at-risk communities and populations. However, as disaster events are often compound in nature, government ministries must be able to coordinate their operations. This will require unified and standardized ICT systems. The National Fire Agency is currently developing a public disaster information platform that standardizes communication with the public during emergencies. Meanwhile, the National Science and Technology Center for Disaster Reduction is also developing the "Disaster Decision Making Information System," which integrates disaster information data from more than 20 government agencies, and presents the data with geographic features (NCDR 2012).

Although these ICT developments would improve communication and decision-making within Taiwan's disaster management system, there are some potential threats to the effectiveness of current ICT systems. First, the system requires human resources to input data and to operate the system. Without the capacity to allow local communities to input data into the system, decision makers would not able to allocate resources effectively. Second, the ICT system relies on data that is collected using the government's traditional hierarchies. If a single agency fails to perform its function, the information system will not be as effective as designed.

There are four things that can be done to overcome these limitations. First, during emergency situations, a staff member can be assigned to a position that is responsible for collecting and entering data into the information system. Second, to close the digital divide between users in the national government and those in the municipal governments, the national government should provide training to the personnel who need to use the information system. Third, the national government should simplify the number of information systems used by

government agencies. Because each ministry and department currently has its own information management system, staff who work in county and municipal governments must currently provide data, in multiple forms, to multiple ministries and departments. The reporting process should be simplified to save time and energy during emergency situations. Fourth, the national government can extend data sources used in the decision making information system by including data from outside of the government. For example, the government can collect data published in the mass media and social media and use it as supplementary sources of information. However, the accuracy of the data from these sources will be a concern. To respond to this concern, the national government can recruit volunteers and provide them with the training they need to verify information.

8.2.4 Engage Nonprofit and Private Organizations in Disaster Management

The findings indicate that nonprofit and private organizations became actively involved in the disaster response process after the studied events. Most of these non-official responders were triggered by the norms of humanitarianism and corporate social responsibility. However, they usually engaged the response system through social connections and performed their functions without effective coordination. In both response systems, we observed the problem of duplicated efforts, unevenly distributed volunteers and resources, and organizational competition. The non-official responders did, however, play a substantial role in the provision of emergency response and relief assistance after the two disasters. To sustain the benefits provided by the voluntary contributions of non-official responders, and to avoid the problems created by the lack of coordination, Taiwan's government should better integrate non-official responders into the activities undertaken within the disaster management system.

The government could assist nonprofit organizations by establishing an umbrella organization for the voluntary organizations that are interested in contributing to disaster management tasks. Similar to the National Voluntary Organizations Active in Disaster (VOAD) in the United States, this organization would not directly provide disaster services. Rather VOAD serves as a coordinator which supports the voluntary organizations that participate in disaster management activities, enabling them to share information, knowledge and resources. This form of coordination can reduce the inefficient distribution of voluntary resources, while allowing nonprofit organizations to maintain their autonomy.

The corporate sector has not played a major role in Taiwan's disaster response system. In both the ChiChi Earthquake and Typhoon Morakot events, private companies usually engaged in the response system through individual relationships. Currently, it is common for government agencies to sign contracts with private companies for the provision of emergency services and supplies during disaster response situations.

The analysis suggests that the government can more actively engage the private sector. For example, the government can work with the private sector to develop disaster insurance plans. Disaster insurance is not a product that is commonly accepted in Taiwan. After disaster events, the government usually plays an ambiguous role in compensating private losses with public resources. The development of insurance products would help those within Taiwan's society to share the costs of disaster. Second, the government should encourage private companies to prepare for emergency situations. If a disaster emergency occurs during business hours, employers should take measures to avoid further damage to their property and to provide appropriate assistance to their employees. The government can include private companies in disaster simulations, enabling them to recognize their roles during emergency situations.

8.2.5 Encourage the Regional Cooperation

According to the design of Taiwan's current disaster management system, disaster response operations follow a hierarchical structure in which county governments only work with the national government and municipal governments. The findings indicate that county governments can develop partnerships with the other counties in their region. These partnerships would not just be built for the purpose of disaster response and recovery, but also for disaster mitigation and preparedness activities. Disasters do not recognize administrative boundaries. Yet, the effective implementation of disaster management policies will usually require organizational actors to cooperate across administrative boundaries. For example, a single county cannot do flood management, as rivers usually cross multiple counties.

Regional cooperation can start with the creation of mutual assistance agreements between fire departments. Fire fighters often receive similar standard training and can communicate using a common language. The national government can provide financial incentives to county governments to encourage such regional cooperation.

8.2.6 Provide the Social Networking Space to Promote Interaction and Trust

Findings indicate that pre-existing social relationships influenced the likelihood that interactions would be initiated among response organizations. These pre-existing social relationships also increased the effectiveness of organizational communication and coordination. However, the extent to which social connections can be built is often associated with geographical distance, areas of expertise, and jurisdictional boundaries. Information technology may be applied to create the social networking space for individual and organizational actors who are from

different locations and who have different backgrounds to meet and interact with each other. Social networking platforms, such as Facebook, Twitter, and Plurk, operate in real time, and overcome the obstacles created by geographical distance.

The experience in Typhoon Morakot showed that social networking sites facilitated information exchange and self-organizing behaviors among individuals, enabling them to mobilize and coordinate resources during an emergency situation. These social networking sites can also be used to encourage interaction, communication, and knowledge sharing among disaster responders from different disciplines during non-emergency situations. By interacting and sharing on social networking platforms, professionals can recognize common interests, as well as the perspectives advanced by various disciplines. These platforms can also be used to build informal connections that may promote cooperation during future disaster events. These interaction processes also can support organizations as they learn to improve their operational performance through their shared experiences.

8.3 FUTURE RESEARCH

8.3.1 Expand Data Sources to Enhance the Validity

Due to time and resource limitations, the network data used in this study was collected from the content of just one national newspaper, *United Daily*. From the research design perspective, the use of a single data source can create concerns about validity. The information in the newspaper was filtered and selected by journalists and editors who may possess specific biases. I minimized the influence of this potential bias by only collecting the names and activities of organizations.

The analysis does not use the content of news articles to make value judgments about organizational performance. Future studies could address this methodological issue by collecting the network data from one more national newspaper, especially those that have different political positions. By comparing the results from the two newspapers, the research will be able to identify the influence of position bias on network analysis data.

8.3.2 Explore the Role of Geographical Space

According to Axelrod and Cohen (2000), the likelihood of actor interaction is influenced by conceptual and physical space. I analyze the characteristics of interaction patterns that are associated with conceptual space, for example, the institutional backgrounds and jurisdictional levels of disaster response organizations. It would be worth further exploring the relationship between geographical location and organizational interaction patterns. To perform this analysis, this study will need to identify the geographic location of each organization contained in the dataset and to conduct a network analysis with the location variables.

8.3.3 Examine the Relationships between Factors and Interaction Patterns

I explored the structure and process factors that influence the formation of disaster response networks. The factors identified in this study promoted and constrained organizational interactions in various ways. Future research could examine how these factors are statistically associated with the network structure measurements generated for each of the response systems. The research methodologies employed in this study did not allow me to conduct such a causal analysis. First, I explored these factors by interviewing the key informants in the system. Their

answers could not objectively reflect the behavior of the organization. Second, the interview content provided by the respondents could not be transformed to quantitative data for testing in regression models. This would require the development of a new casual model, which could then be used to examine the relationships between the factors and the interaction patterns.

8.3.4 Evaluate the Learning Capacity of Counties and Municipal Governments

This study analyzed the performance of the Taiwan's disaster response system after two focusing events. Because the impacted regions were different in the two cases, I could not directly examine the extent to which county and municipal governments' learned new patterns of performance during the period of time that separated the two disaster events. Future studies could employ a research design that would focus on specific types of disaster events, such as typhoons. There are five to six typhoons on average that impact Taiwan in each year. With such a high frequency, a study will have larger "N" to detect and analyze changes in performance by the county and municipal governments. Such a study would also enable researchers to identify policy changes after each disaster event, and to evaluate the success of those policy changes.

8.3.5 Investigate the Influence of Reorganization of Government Structure on the Operation of Taiwan's Disaster Management System

In the years since 2010, Taiwan's government has reorganized elements of its administrative structure. For example, in December 2010, Taipei County was upgraded to a special municipality and renamed New Taipei City. In addition, Taichung City and Taichung County were consolidated and together upgraded to become a unified special municipality. Similar

consolidations occurred with Tainan City and Tainan County, and Kaohsiung City and Kaohsiung County. In 2014, the Taoyuan County will also be upgraded to a special municipality.

The consolidation and reorganization of administrative divisions changed the structure of government and may influence the operation of the disaster response system. First, the power relationship between the townships at the municipal level and special municipalities has changed. The mayors of municipal governments used to be directly elected, and the municipal government had the authority to allocate its own budget. After the administrative reforms, municipal governments have become administrative district offices, and the municipal governments have the authority to nominate the officer of each district and allocate the financial budget for each district. Second, the cities and counties usually have different geographical characteristics. After the consolidation, the special municipalities now contain both urban and rural areas within their administrative boundaries. This means that the types of disaster risks faced by government agencies have evolved. Government agencies, as well as the disaster management plans and polices, must also change to meet these new risks.

Future research can examine how the changes in Taiwan's governmental structures may influence the operation of its disaster management system. With the new structure, the special municipality governments now have the responsibility and authority to direct disaster response operations in local districts. The consolidation also requires the personnel and emergency responders who used to work in the city or in the county to recognize new operational boundaries and to become familiar with the geographical features of their new areas of responsibility. The reorganization of government may also change the patterns of interaction and communication among the organizations in the disaster management system. In short, the changes that have been

made to Taiwan's formal and informal structures may affect the performance of its disaster management and response system.

APPENDIX A

LIST OF SEMI-STRUCTURED INTERVIEW SUBJECTS, DATE AND LOCATION

ID	Organizations	Source of Funding	Jurisdiction Level	Interviewee's Position	Interview Date	Interview Location	Events
G1	Pingtung County Government	Public	County	Upper Management	11/08/2011	Pingtung City	C/M *
G2	Fire Department of Pingtung County Government	Public	County	Upper Management	11/08/2011	Pingtung City	M
G3	Directorate General of Highways, Ministry of Transpiration and Communication, Executive Yuan	Public	National	Upper Management	11/09/2011	Taipei City	M
G4	The 921 Earthquake Post-Disaster Recover Commission, Executive Yuan	Public	National	Middle Management	11/14/2011	Taipei City	C
G5	Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan	Public	National	Upper Manager	11/15/2011	Taipei City	M
G6	Fire Department of Taichung County Government	Public	County	Upper Management	11/16/2011	Taipei City	C
G7	Office of Disaster Management, Executive Yuan	Public	National	Middle Management	11/17/2011	Taipei City	M
G8	Water Resources Agency, Ministry of Economic Affairs, Executive Yuan	Public	National	Middle Management	11/18/2011	Taipei City	M
G9	Department of Social affairs, Tainan County Government	Public	County	Middle Management	11/20/2011	Taipei City	M
G10	National Fire Agency of the Ministry of Interior, Executive Yuan	Public	National	Upper Management	11/22/2011	Taipei City	M
G11	Department of Social Affairs, Ministry of Interior	Public	National	Middle Management	11/22/2011	Taipei City	M

G12	Kaohsiung County Government	Public	County	Upper Management	11/23/2011	Kaohsiung City	M
G13	Fire Department of Nantou County Government	Public	County	Upper Management	11/24/2011	Nantou City	C
G14	Ministry of National Defense	Public	National	Upper Management	11/30/2011	Taipei City	C/M
G15	Central Emergency Operation Center	Public	National	Middle Management	12/02/2011	Taipei City	M
G16	Public Health Center of Liouguei Township, Kaohsiung County	Public	Municipal	Upper Management	12/07/2011	Liouguei Town, Kaohsiung County	M
G17	Liouguei Township, Kaohsiung County	Public	Municipal	Middle Management	12/07/2011	Liouguei Town, Kaohsiung County	M
G18	Tsautuen Township, Nantou County	Public	Municipal	Upper Management	12/08/2011	Tsautuen Town, Nantou County	C
G19	Lugu Township, Nantou County	Public	Municipal	Upper Management	12/09/2011	Nantou City	C
G20	Police Broadcasting Service	Public	County	Middle Management	12/13/2011	Taichung City	C
G21	National Fire Agency, the Ministry of Interior, Executive Yuan	Public	National	Middle Management	12/19/2011	Taipei City	C
G22	Wufeng Township, Taichung County Government	Public	Municipal	Middle Management	12/26/2011	Wufeng Town, Taichung County	C
G23	Department of Social Affairs, Kaohsiung County Government	Public	County	Middle Management	12/29/2011	Pingtung City	M
G24	Department of Social Affairs, Taichung County Government	Public	County	Middle Management	12/30/2011	Taichung City	C
N1	Taiwan Red Cross	Nonprofit	National	Upper Management	11/03/2011	Taipei City	M
N2	Association of Digital Culture Taiwan	Nonprofit	National	Middle Management	11/04/2011	Taipei City	M
N3	Association of Mountain Search and Rescue of Taiwan	Nonprofit	National	Upper Management	11/08/2011	Pingtung County	M
N4	The Presbyterian Church in Taiwan	Nonprofit	National	Upper Management	11/11/2011	Taipei City	M
N5	Chishang Hospital, Department of Health, Executive Yuan	Nonprofit	County	Upper Management	11/24/2011	Chishang Town, Kaohsiung County	M
N6	World Vision Taiwan	Nonprofit	National	Upper Management	11/25/2011	Taipei City	C/M
N7	Begonia Foundation	Nonprofit	National	Upper Management	12/01/2011	Taipei City	C/M
N8	Search and Rescue Association of	Nonprofit	County	Upper	12/06/2011	Kaohsiung City	C/M

	Kaohsiung County			Management			
N9	Red Cross of Nantou County	Nonprofit	County	Upper Management	12/08/2011	Nantou City	C/M
N10	The Presbyterian Church in Taiwan	Nonprofit	County	Middle Management	12/11/2011	Taimali Town, Taitung County	M
N11	The Presbyterian Church in Taiwan	Nonprofit	National	Upper Management	12/14/2011	Taipei City	C
N12	Tzuchi Foundation	Nonprofit	National	Middle Management	12/20/2011	Hwalien City	C/M
N13	Tzuchi Foundation	Nonprofit	National	Middle Management	12/20/2011	Hwalien County	M
N14	Dharma Drum Mountain Social Welfare and Charity Foundation	Nonprofit	National	Upper Management	01/12/2012	Taipei City	C
P1	Carrefour Company, Taiwan	Private	National	Upper Management	11/16/2011	Taipei City	M
P2	President Chain Store Corporation	Private	National	Middle Management	12/28/2011	Taipei City	M
P3	Daai Technology Corporation	Private	National	Upper Management	12/28/2011	Taipei City	M
P4	United Daily News	Private	National	Upper Management	01/10/2011	Taipei City	C

* C = The ChiChi Earthquake; M = Typhoon Morakot;

C/M = the interviewee had talked about the experience of both events

APPENDIX B

SEMI-STRUCTURE INTERVIEW PROTOCOL

B.1 PROTOCOL IN ENGLISH

1. On what day after the event did your organization respond?
2. What role, if any, did your organization play in response operations during the first three weeks after ChiChi Earthquake / Typhoon Morakot happened?
3. In your judgment, what were the primary goals that your organization tried to achieve during the first three weeks after the ChiChi Earthquake / Typhoon Morakot?
4. In your judgment, what were the major problems that your organization encountered during the first three weeks after the ChiChi Earthquake / Typhoon Morakot?
5. What were the major actions your organization took to solve the problems during the first three weeks after the ChiChi Earthquake / Typhoon Morakot?
6. Please describe the processes that your organization used to manage information regarding its interactions with other organizations during response operations.
7. What other organizations did your organization work with during the first three weeks after the ChiChi Earthquake / Typhoon Morakot?
    a. For what purpose you worked with these organizations?

b. What kind of interactions did you participate?
c. How were the interactions with these organizations initiated?
d. How did you communicate and coordinate with these organizations?

8. What were the legal mandates that influenced your organization's decision making processes:

    a. during the first three weeks after the ChiChi Earthquake?
    b. during the first three weeks after Typhoon Morakot?

9. What were operational practices of your organization's decision making processes?

    a. during the first three weeks after the ChiChi Earthquake?
    b. during the first three weeks after Typhoon Morakot?

10. In your judgment, what were the strengths of Taiwan's emergency response system that operated:

    a. during the first three weeks after the ChiChi Earthquake?
    b. during the first three weeks after Typhoon Morakot?

11. In your judgment, what were the weaknesses of Taiwan's emergency response system that operated:

    a. during the first three weeks after the ChiChi Earthquake?
    b. during the first three weeks after Typhoon Morakot?

12. In what ways, has Taiwan's emergency response system developed:

    a. After the ChiChi Earthquake?
    b. After the Typhoon Morakot?

13. In your judgment, what are the current strengths of Taiwan's emergency response system?

14. In your judgment, what are the current weaknesses of Taiwan's emergency response system?

15. What are the recommendations you would give to improve Taiwan's future emergency system?

16. Thank you for talking with me. Is there anything you would like to add?

B.2 PROTOCOL IN CHINESE – THE CHICHI EARTHQUAKE

1. 請您談一談貴組織是在哪一天開始投入九二一地震救災工作，以及當時主要的救災任務？

2. 請問貴組織從事九二一地震救災工作時，所遭遇的主要困難為何？貴組織採取了什麼樣的行動來解決困難？

3. 請您談一談在救災期間，貴組織如何蒐集、運用、並與其他組織分享決策時所需要的相關資訊？

4. 貴組織在從事救災工作的時候，是否曾經其他組織合作？是否可以請您談談互動的過程？

5. 請問在參與九二一救災工作過程，有那些因素影響貴組織的決策過程？（例如：法令規章等…）

6. 就您判斷，在緊急回應九二一地震災變期間，台灣的災害緊急應變體系的優缺點為何？

7. 就您觀察，在九二一地震發生之後到目前為止，台灣的災害緊急應變體系有什麼發展與變化？

8. 就您判斷，台灣當今的災害緊急應變體系有哪些優缺點？您建議應該如何提昇台灣當今的災害緊急應變體系？

B.3 PROTOCOL IN CHINESE – TYPHOON MORAKOT

1. 請您談一談貴組織是在哪一天開始投入莫拉克颱風救災工作，以及當時主要的救災任務？
2. 請問貴組織從事莫拉克颱風救災工作時，所遭遇的主要困難為何？貴組織採取了什麼樣的行動來解決困難？
3. 請您談一談在救災期間，貴組織如何蒐集、運用、並與其他組織分享決策所需要的相關資訊？
4. 貴組織在從事救災工作的時候，是否曾經其他組織合作？是否可以請您談談互動的過程？
5. 請問在參與莫拉克颱風救災工作過程，有那些因素影響貴組織的決策過程？（例如：法令規章等...）
6. 就您判斷，在緊急回應莫拉克颱風災變期間，台灣的災害緊急應變體系的優缺點為何？
7. 就您觀察，在莫拉克風災發生之後到目前為止，台灣的災害緊急應變體系有什麼發展與變化？
8. 就您判斷，台灣當今的災害緊急應變體系有哪些優缺點？您建議應該如何提昇台灣當今的災害緊急應變體系？

APPENDIX C

INTERVIEW ANALYSIS CODES

Category	Concept	Codes
Functions and Goals	Emergency Response	Evacuation
		Search and Rescue
		Confirm Clients and Resident Safety
		Emergency Medical Care
	Disaster Relief	Sheltering
		Provide Supplies
	Administrative Operations	Coordinate Response Measures
		Collect and Reporting Information
		Mobilize and Manage Resources and Supplies
	Restore and Recover	Restore Lifeline System: Roadways, Water, Gas, Telecommunication and Electricity Infrastructure
Challenges and Difficulties	Emergency	Highly Dynamic and Time Constraints
	Lack of Information for Decision Making	Disrupted Information and Communication Infrastructure
		Inaccurate Information
	Chaotic Commend System	Local Governments Collapsed
		Lack of Disaster Response Plans and SOP
		Divided Response Functions
	Under Capacity	Lack of Equipment
		Lack of Manpower
	Overloaded Donations and Volunteers	Demand and Supplies were not Matched
		Lack of Logistic and Coordination Mechanism
	Weak Local Government	Disaster Response Resources were Unevenly Distributed Among Urban and Rural Areas
		External Responders not Equipped with Regional and Local Knowledge
	Lack of Risk Awareness	Misjudged the situations and risks
		Failed to Evacuate and Prepare for Risk
Structure Factors	Formal Institutions	Lack of Formal Institutions to Follow in the ChiChi Earthquake case
		Communicate Through Hierarchy Structure
		Pursue Legal Responsibility
		Hierarchical Communication Structure Delayed

		Information Distribution
	Information and Communication Technology	Essential for Sharing and Exchanging Information
		Support Decision Making Process
	Actor Attributes	Public Organizations Gain More Trust
		Conceptual Distance Increased the Difficulty of Communication and Coordination Among Organizations
Process Factors	Social Connections	Preexisted Relationships Facilitated Interactions
		Personal Connections were Utilized for Seeking Resources
		NPOs Interact with Other Organizations Through Clients and Members
	Norms	Emergent Norms of Humanitarianism and Voluntarism During Emergency Situation
		NPOs and Private Companies Actively Engaged in Disaster Response
		Conflict Norms Between Emergency Response and Bureaucratic System
	Culture	Organizational Culture of Exploring External Resources
		Culture Barriers Could Have Constrained Interactions
		Culture of Political Cleavage and Polarization Constrained Interactions
	Utilization of ICTs	ICTs did not Function as Expected
		Adapt and Adopt ICTs Available in the Context
	Leadership	Effective Leader could Promote Interactions through Breaking Legal Limitations
		Leaders' Attitude Constrains Interactions
System Change After ChiChi Earthquake	Change of Formal Institutions	Revised Building Codes
		Passed the Act
		Developed Emergency Management Plans
		Establish Emergency Medical Services Networks
	Investments in Equipment and Human Resources	Establish Special Search and Rescue Squad
		Purchased Search and Rescue Equipment
		Establish Airborne Rescue Team
		Provide Trainings to Fire Fighters
	Advanced Risk Management	Investigate Potential Risk Area
	NPOs Enhanced their Capacity	Invested in Training and Equipment
		Develop Emergency Response Mechanism
		Build Alliance with other NPOs
System Change After Typhoon Morakot	Change of Formal Institutions	Formally Included the Military into the Disaster Management System
		Adjust the Organization of Disaster Management Structure
	Emphasis on Disaster Preparation Measures	Evacuate Residents in Risk Area
		Require Local Communities to Prepare Essential Supplies
	Improve the Communication and Decision Making Process through ICTs	Enhance the Operation of Emergency Management Information System
		Integrate Disaster Intelligence Information Among Ministries
		Build Backup Facilities for Emergency Operations
		Invest to improve communication equipment in

		local
	Improve Knowledge and Risk Awareness	Cooperate with Research Institutes
		Adopt ICT to Deliver Warnings to the Public
		Simulation Practices
	Engaged Nongovernmental Actors	Contract with Private Companies
		Include Nonprofit Organizations in the Disaster Simulation Practice
		Engage Volunteers to Monitor Environment Conditions
Change and Learning	Factors that Promoted Change and Learning	Focus Events as a Trigger Promote Change
		Learning from Experience
		Individuals Learn from experience
		Learn from Aftermath Meetings
	Factors that Inhibited Change and Learning	Path Dependence
		Lack of Resources
		Difficult to Transfer Individual Experiences to Organizational Knowledge
		Lack of Authority to Integrate Disaster Management Policies and Measures

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