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Enhancing the Collaborative Governance in Post-disaster Reconstruction: A Dynamic Performance Management Approach

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Abstract

The impact of natural disasters on human life was blatantly demonstrated through media reports of recent events such as the Ache tsunami in 2004, Hurricane Katrina in 2005, the Wenchuan Earthquake in 2008 and Tohoku Earthquake and Tsunami in 2010-2011. Rising from the rubbles, our societies strive to learn from the experiences how to build a better life and avoid future catastrophes. Post-disaster reconstruction (PDR) plays a crucial role in providing a safer and more resilient living environment for people, particularly for those disaster victims. This thesis focused on how implementing a collaborative governance approach in post-disaster reconstruction can offer effective solutions to enhance future post-disaster reconstruction and recovery efforts. To pursue such a goal an outcome-based Dynamic Performance Management (DPM) perspective has been adopted. The main results of this study are as follows:

This research supports collaborative governance can help the post-disaster reconstruction phase, using the lens of the DPM framework. Usage of the DPM approach represents a novel approach to frame the performance outcomes of collaborative governance in post-disaster reconstruction. Based on the study of ten huge disasters since 2000, this research applies the DPM approach to makes explicit how available strategic resources may impact on performance drivers, thereby influencing the outcomes of collaboration. Therefore, it offers a framework to support decision-makers in identifying key measures (e.g., the attractiveness of collaboration, government credibility ratio) and to design effective policies to improve collaborative governance in post-disaster reconstruction activities.

This research uses the system dynamics (SD) methodology to analyze the dynamic features of a collaborative governance approach in post-disaster reconstruction. In this research, the interactions of multi-stakeholders in post-disaster reconstruction are investigated and made explicit in a SD simulation model. The dynamic of resource supply, reconstruction, resource allocation, and collaborative governance among the government, profit and non-profit organizations, and the public were modeled. The research findings can support decision makers in the effective implementation of reconstruction practices (e.g., reconstruction progress, economic

recovery) and in the improvement of social-economic indicators (e.g., government credibility, citizen satisfaction). Government credibility also demonstrated to play an important role in the successful implementation of a collaborative governance approach.

This research demonstrates that "Paired Assistance Policy" collaborative governance reconstruction mode in post-Wenchuan Earthquake reconstruction is more efficient than traditional mode by using SD modelling approach. The Wenchuan Earthquake offers an illuminating case study for better understanding the dynamic collaborative governance in post-disaster reconstruction. This research analyzes the special "Paired Assistance Policy" (PAP) collaborative governance mode of in post-Wenchuan Earthquake reconstruction and presents a SD model to identify the key factors impacting on the outcomes of the PAP collaborative governance mode. The findings demonstrate that the PAP collaborative governance mode fosters efficiency and effectiveness in post-disaster reconstruction and recovery. Meanwhile, it reveals that the balance between central and local government and paired assisting parities is necessary to improve the outcomes of collaborative governance.

Overall, this research enriches the outcome-oriented view of performance management, with a deep understanding of the development of collaborative governance system. It offers new knowledge on the dynamic and complex effects of collaborative governance on post-reconstruction practices.

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Chapter 1 Research design and focus

1.1 Introduction

Over the past decades, owing to the increased frequency and scope of natural disasters, countries became more vulnerable. The impact of natural disasters on human life was blatantly demonstrated through media reports of recent events such as the Ache tsunami in 2004, Hurricane Katrina in 2005, the Wenchuan earthquake in 2008 and Tohoku Earthquake and Tsunami in 2010-2011. Rising from the rubbles, our societies strive to learn from the experiences how to build a better life and avoid future catastrophes. Post-disaster reconstruction (PDR) plays a crucial role in providing a safer and more resilient living environment for people, particularly for those disaster victims. This thesis focused on how implementing a collaborative governance approach in post-disaster reconstruction can offer effective solutions to enhance future post-disaster reconstruction and recovery efforts. To pursue such a goal an outcome-based Dynamic Performance Management (DPM) perspective has been adopted.

In order to understand the role of collaborative governance in post-disaster reconstruction practices, the next section defines and explains the nature of disasters, demonstrating the importance of the post-disaster reconstruction phase. Then the complexity of post-disaster reconstruction is analyzed, and the relevance of collaborative governance outlined.

1.2 Background

1.2.1 Disaster

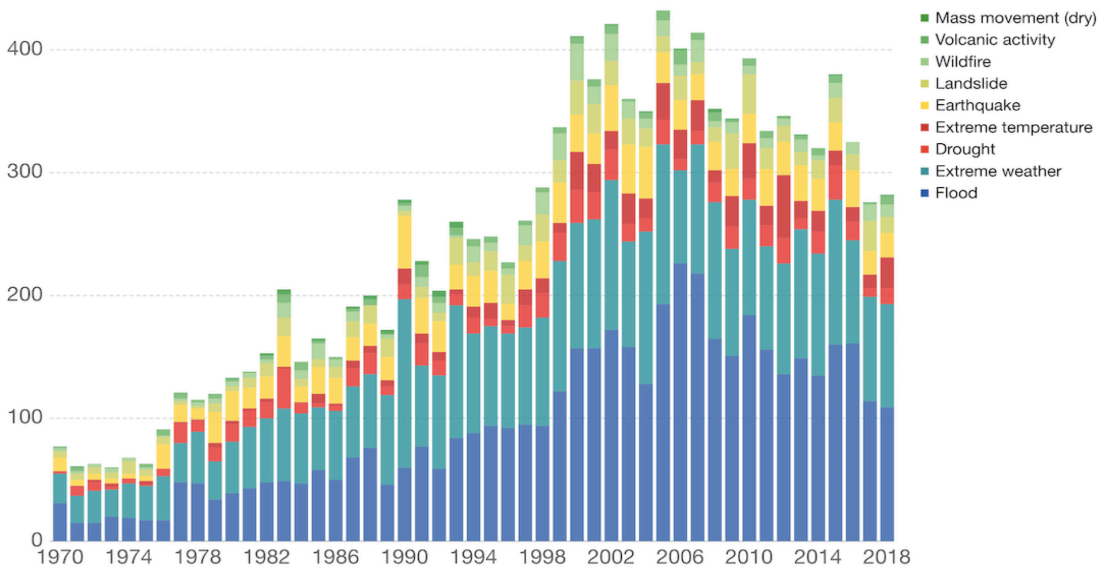
The term ‘disaster’ has increasingly become a buzz word in daily life as the number and scale of disaster events triggered by all hazards continues to rise at an unimaginable rate (UNISDR, 2016). The scoping study of disasters and their impacts on society or communities has gained prominence as a result. Many organizations operating in the disaster management sector have defined and described disaster in a number of different ways:

"A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources" – The United Nations Office for Disaster Risk Reduction (UNISDR)

"A serious disruption of the functioning of society, causing widespread human, material, or environmental losses which exceed the ability of affected society to cope using only its own resources" – United Nations

Carter (1991, p. xxiii) defines a disaster as "an event, natural or man-made, sudden or progressive, which impacts with such severity that the affected community has to respond by taking exceptional measures". Along with Carter, the South Asia Disaster Report (DNS & PA, 2005) states that disasters are produced due to the weaknesses and vulnerabilities of communities, countries and structures to withstand encountered hazards. The different types of hazards can be categorized as: Environmental; Technological; Biological; and Social (Mitchell, 1999). Environmental hazards are caused by natural phenomena such as meteorological conditions and geological conditions. Technological or Man-made hazards are events resulting from human activities such as industrial accidents, nuclear radiation, environmental pollution and chemical leaks. Biological hazards refer to biological substances that pose a threat to the health of living organisms, primarily that of humans. Social hazards, also called complex emergencies, are those which lead to vulnerability of entire populations such as acts of terrorism and internal warfare. The Centre for Research on the Epidemiology for Disasters (CRED) and Munich Re established a collaborative initiative, to implement a common "Disaster Category Classification and Peril Terminology for Operational Databases" in 2007 (Below et al., 2009). The classification differentiates between two generic disaster categories: (1) Natural hazards, grouping together environmental and biological hazards and (2) Technological or Man-made hazards, grouping together technological and social hazards.

Both natural and technological/man-made disasters have seen nearly exponential rises in the number of disasters and lead to great economic loss of our society over time, especially natural disasters. The statistics from EM-DAT show that 86% of disaster related deaths were due to natural disasters proving natural disasters to be a major concern for communities. Figure 1.1 shows the global reported natural disasters by type over the period between 1970 and 2018, while figure 1.2 shows the global economic damage by natural disasters type over the same period. According to CRED's figures, in 2018, there were 315 natural disaster events recorded with 11,804 deaths, over 68 million people affected, and US$131.7 billion in economic losses across the world. The far-reaching impact of devastating natural disasters on the economy and society are substantial and are clearly on the rise (Abramovitz, 2001). The disaster management has been a critical challenge faced by researchers and practitioners worldwide.



(OFDA/CRED International Disaster Database)

Figure 1.1 Global reported natural disasters by type

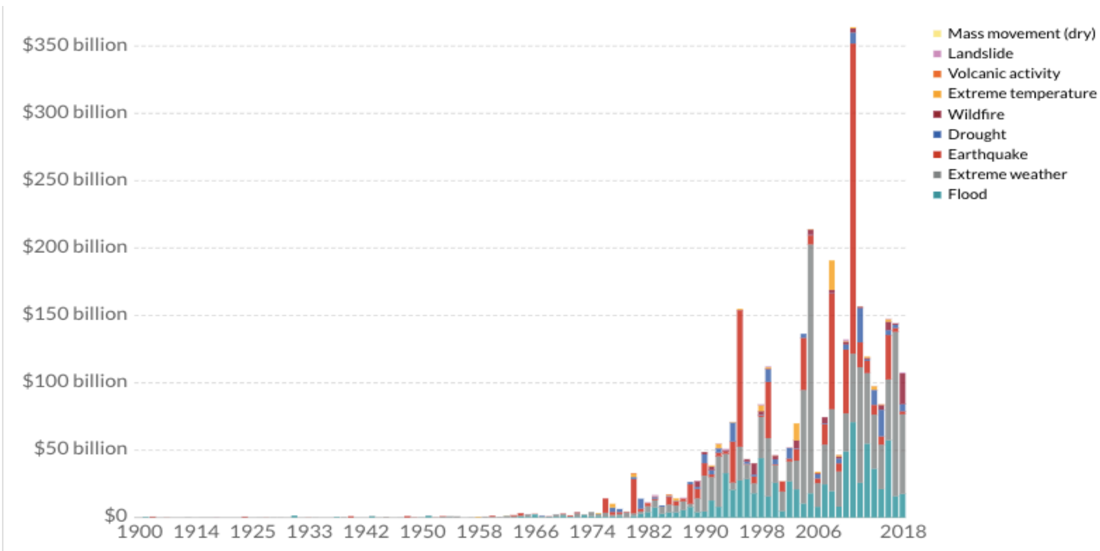


Figure 1.2 Global economic damage by natural disasters type
(OFDA/CRED International Disaster Database)

1.2.2 The importance of post-disaster reconstruction

Four phases commonly represent disaster management: Mitigation, Preparedness, Response and Recovery (Rubin, 1991). The author carefully examined governmental organization and processes for community-level recovery by looking at 14 disasters of several different types from throughout the U.S. The same phases have been recognized under various names in different countries. For example, in New Zealand, the Ministry of Civil Defence and Emergency Management refers to them as the — 4 Rs: Reduction, Readiness, Response and Recovery (Ministry of Civil Defence and Emergency Management, 2013).

Figure 1.3 provides an overview of the “phases” of disaster management and main tasks needed to be emphasized in each phase. As illustrated in Figure 1.3, the four phases are often described as part of a continuous process. McEntire (2006) suggests that these phases should not be understood and interpreted in a linear fashion but should instead be viewed as functional areas that usually overlap each other. For instance, mitigation and preparedness both address the need to proactively prepare for disasters and apply disaster and risk reduction strategies. The strategies applied in the pre-disaster phase certainly impact the ways in which communities and agencies respond to incidents (Alesch et al. 2009; Kapucu & Ozerdem 2013).

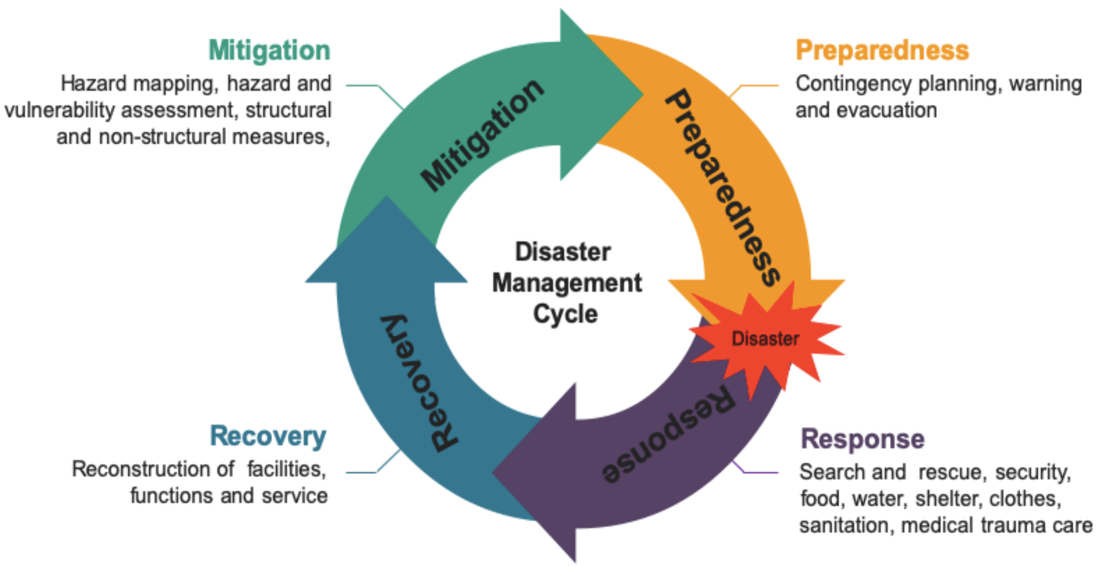


Figure 1.3 Disaster management cycle
(Adapted from NEHRP, 2009)

Reconstruction Following Disaster, by Haas et al. (1977) was the first study to take a comprehensive view of the recovery process. Their research examined two recent (1972 Rapid City flood, 1972 Managua, Nicaragua earthquake) and two older (1964 Alaska earthquake, 1906 San Francisco earthquake) disasters in order to identify common policy issues and extract common lessons on the forces that affect reshaping of a city following disaster. Haas et al. (1977) broke down the activities following a disaster into four periods (Figure 1.4):

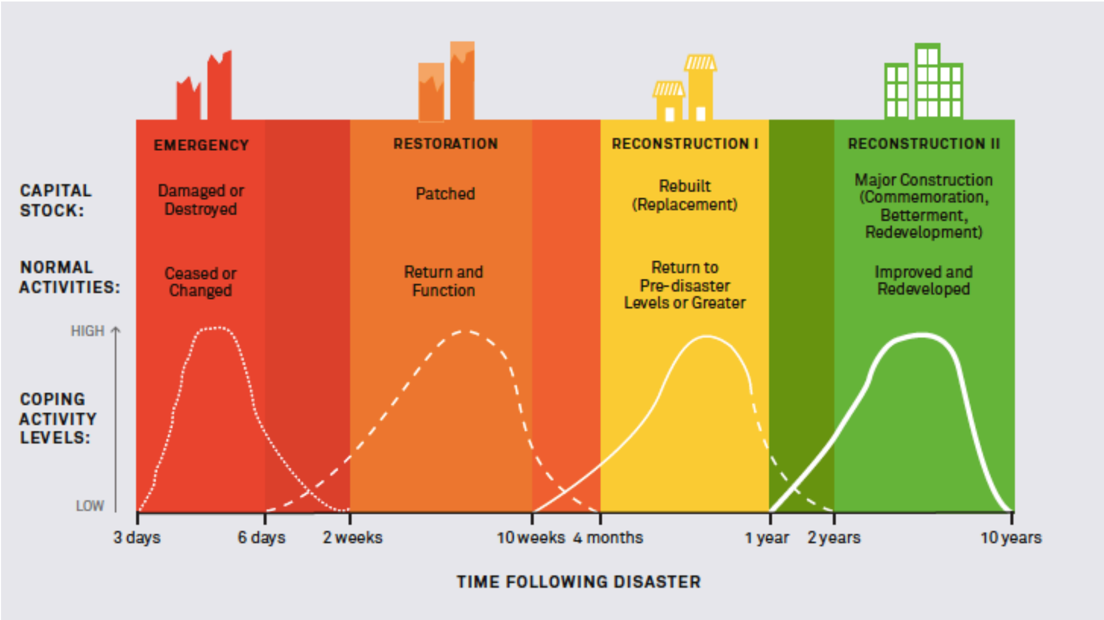


Figure 1.4 Time following disaster
(Haas et al., 1977)

1. The Emergency Period – the initial period following a disaster, usually ranging from a few hours to a few days. Normal community functions are disrupted, and beginnings of the clean-up are initiated.
2. Restoration Period – the period where major services, communication and transportation are restored. This period can take from several weeks to a few months.
3. Replacement Reconstruction Period – the built environment is restored to pre-disaster levels and social and economic activities are returned to pre-disaster levels or higher.

4. Commemorative, Betterment and Developmental Reconstruction Period – period where memorials and commemoration take place, as well as major construction activities to improve the city for future growth and development.

Figure 1.4 also illustrates emergency takes effect immediately during and after the incident, while the restoration and reconstruction phase, as depicted in the figure, slightly overlaps the response phase and continues at the beginning of next phase. Traditionally, post-disaster reconstruction consisted of simply repairing the physical damage that has been induced by a disaster. However, authors such as Kennedy et al. (2008) and Lyons (2009) pointed out that rebuilding the built environment and infrastructure exactly as they were prior to a disaster often re-creates the same vulnerabilities that existed earlier. Poor PDR efforts can lead to instability, vulnerability, poverty, or the combination of them, which is often evident in developing countries (El-Masri & Tipple, 2002). For disaster-prone regions in developing countries, PDR can also provide a rare opportunity for the local society to build a better place with multiple objectives.

After the worst is over, PDR is a very important aspect of work as it provides long-term developmental guidance. As stated in Safer homes, stronger communities: a handbook for reconstructing after natural disasters published by World Bank (Jha, 2010, viii): "Post Disaster Reconstruction begins with a series of decisions that must be made almost immediately. Despite the urgency with which these decisions are made, they have long-term impacts, changing the lives of those affected by the disaster for years to come." Even though the increasing number of post-disaster reconstruction experiences encountered, this phase still remains inefficient and poorly managed (Halvorson & Hamilton, 2010; Lloyd-Jones, 2006; Sawyer et al., 2010). Therefore, the reconstruction period and recovery phase needed to be furtherly studied and improved.

1.2.3 The inception of collaborative governance in post-disaster reconstruction

The increasing frequency of disaster events in recent times has led to a demand for improved post-disaster reconstruction and recovery efforts. The complex nature of recovery planning and efforts requires pre-disaster and post-disaster collaboration between different recovery stakeholders. Collaborative governance is being utilized and applied to manage disasters due to the catastrophic effects of disasters that are beyond the scope of any single jurisdiction or sector.

Collaborative governance (CG) is a form of governing where both public and private entities are involved in collective and consensus-oriented decision-making (Ansell & Gash, 2007; Emerson et al., 2012; Kapucu, 2012). It emphasizes collaboration which is beyond mere coordination and requires the achievement of shared goals and shared decision-making through both inter-organizational and cross-sector efforts and relationships (Agranoff & McGuire, 2003; Bardach, 1998; Bryson et al., 2006). It has been defined and described in a number of different ways:

"A governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative and that aims to make or implement public policy or manage public programs or assets." – (Ansell & Gash，2007)

"The processes and structures of public policy decision making and management that engage people . . . across the boundaries of public agencies, levels of government, and/or the public, private, and civic spheres to carry out a public purpose that could not otherwise be accomplished." – (Emerson & Nabatchi, 2015)

The concept of collaborative governance based on the relationship among participants in post-disaster reconstruction has become an increasingly popular explanatory tool. After a disaster happens, state and local governments are tasked to help their citizens to recover from disasters. However, when a disaster overburdens the capacity of local and state government's federal assistance then becomes available. Public assistance, as the name suggests, is the federal assistance available to public entities such as state, local governments or non-governmental agencies that provide public services such as education, utilities, medical and rehabilitation etc. This type of assistance can finance and support the "repair, restoration, reconstruction, or replacement of a public facility or infrastructure that is damaged or destroyed" (NGA, 2007, p. 48).

1.3 Statement of the problem

The discussion on the participants, their interactions, and their participating effectiveness in post-disaster recovery has been well researched (Gao, 2012; Waugh & Smith, 2006; Kapucu, 2014). However, such studies primarily address the performance of a single participant or interaction at a certain moment of post-disaster recovery. They lack long-term and continuous observation throughout the reconstruction process to evaluate the disaster reconstruction practice from collaborative governance and integrated framework perspectives.

Merely recognizing the importance of collaborative governance in post-disaster reconstruction and establishing a set of generalized guidelines for the collaborative governance framework without understanding how the key stakeholders interact with each other and how this interactions feedback on post-disaster reconstruction has prevented actual building back better. More investigations and an outcome-based approach are required on what affects the implementation of collaborative governance in post-disaster reconstruction, and how collaborative governance can contribute to achieving better post-disaster reconstruction. Therefore, this research investigates collaborative governance in post-disaster reconstruction through a deductive-inductive approach where qualitative research strategies assume a descriptive account in accordance with the Dynamic Performance Management (DPM) approaches.

1.4 Theoretical framework

The failure to understand and analyze the collaborative governance in post-disaster reconstruction practice, as explained in former sessions, indicates a gap in knowledge regarding multiple aspects. For instance, how collaborative governance in post-disaster reconstruction can be better recognized and more clearly defined, and how it can enhance post-disaster reconstruction effectiveness.

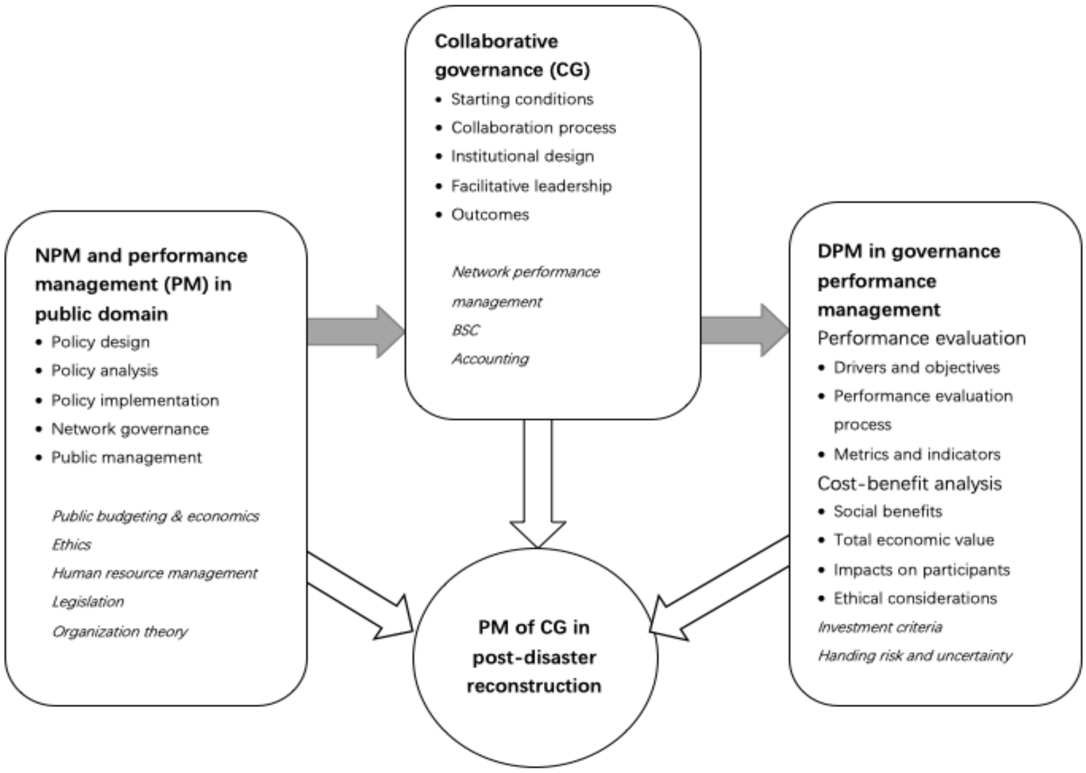


Figure 1.5 A diagram of the theoretical framework

To fulfil this gap, this study refers to three main theoretical streams of research: (i) the New Public Management and Performance Management in public domain; (ii) Collaborative Governance, and (iii) the Dynamic Performance Management. Figure 1.4 illustrates how the relevant theoretical framework supports this research in detail. In the same figure, in smaller *italic* font are mentioned those areas excluded from this literature review.

1.5 Research questions and objectives

This study focuses on the introduction of a collaborative governance, using the DPM perspective, exclusively on post-disaster reconstruction, i.e., those activities undertaken after the emergency and restoration phases. This decision can be justified based on the characteristics of such initial stages. They often last a few weeks or months and the promptness of the intervention to rescue human lives drives all activities. Although collaborative governance can play an important role in all phases, post-disaster reconstruction and recovery phases peculiarities (e.g., longer time horizon in which they generate effects) appear coherent to investigate how collaborative governance fosters efficiency and effectiveness in post-disaster reconstruction and recovery. This choice is also consistent with the use of the DPM perspective, which outline how the relationships between strategic resources, performance drivers and related outcomes impact on post-disaster reconstruction and recovery results over time.

Therefore, there are four main research questions will be addressed in this study as shown in Table 1.1.

Table 1.1 Research questions

RQ#	Research Questions
RQ 1	Can a collaborative governance approach improve post-disaster reconstruction?
RQ 2	How a collaborative governance approach improves post-disaster reconstruction?
RQ 3	Can the use of the DPM perspective facilitate the implementation of collaborative governance in the post-disaster reconstruction?
RQ 4	How the use of the DPM perspective facilitates the implementation of collaborative governance in the post-disaster reconstruction?

These over-arching questions can be broken down into the following sub-questions:

- What is collaborative governance in post-disaster reconstruction?
- Who are the key stakeholders in collaborative governance?
- How do the key stakeholders in collaborative governance relate to each other?
- What are the main outcomes and performance drivers of the collaborative governance in post-disaster reconstruction?
- What are the interactions and feedback loops among these factors?
- How to intervene these interactions and feedback loops in order to obtain sustainable post-disaster reconstruction?
- Does collaborative governance in post-disaster reconstruction work better than traditional mode?

Answers to the above research questions are sought using the below set of objectives:

1) Define collaborative governance in post-disaster reconstruction. This objective allows "Collaborative Governance" to be understood and defined to form the basis of the framework that will be developed throughout this study. Key concepts which represent collaborative governance can be developed based on this understanding.
2) Identify the key stakeholders in collaborative governance. Through emphasizing the multiple sectors that come together in an integrated post-disaster reconstruction management approach, it helps not only to determine who the stakeholders are but also to determine the best ways to manage their participation.
3) Recognize the collaboration between key stakeholders. Understand what the development of partnerships in practice is and how it works.
4) Produce a DPM framework which describes the main outcomes and drivers of the collaborative governance in post-disaster reconstruction. Its objective is to demonstrate that DPM enhance the collaborative governance in post-disaster reconstruction.
5) Build causal loop diagrams and system dynamics model to explicate the interactions and feedback loops so as to understand the dynamic behavior of collaborative governance in post-disaster reconstruction.
6) Conducting policy analysis of this system dynamics model to provide practical suggestions for post-disaster reconstruction practitioners to enhance the collaborative governance and undertake reconstruction and recovery activities better.
7) Applying the system dynamics model to a practical case. Using the case of Wenchuan Earthquake to analyze whether the "Paired Assistance Policy" reconstruction mode more sufficient than traditional mode.

1.6 Overview of methodology

1.6.1 System dynamics modelling

Public Management is a broad field that encompasses a wide range of scientific interests, which includes the process of developing and implementing public policies on the one hand, and the delivery of public services on the other. This work applies the findings of explanatory studies into a research area which aims to "bridge the gap between Systems Dynamics and its applications in organizations, with a precise focus on performance management" (Bianchi, 2016, vii).

The system dynamics methodology is well suited to address the dynamic complexity that characterizes many public management issues (Homer & Hirsch, 2006). "Despite the high applicability to public policy problems, system dynamics is currently not utilized to its full potential in government policy making" (Ghaffarzadegan et al., 2011). System Dynamic design and implementation have often generated an illusion of control and a risk of manipulation in goal setting and performance evaluation (Bianchi, 2010).

System dynamics can assist in strategy assessment and provides insights into possible changes in the system during policy implementation (Sterman, 2000). In this study, Dynamic Performance Management (DPM) and system dynamics modelling is used to simulate the collaborative governance in post-disaster reconstruction. DPM proved to be highly effective for addressing the complexity of the wicked issues (Bianchi et al., 2017; Bivona, 2015; Cosenz & Bianchi, 2014; Cosenz, 2014, Noto & Bianchi, 2015). By using the system dynamics techniques all the necessary variables to assume a whole city system can be considered easily with their changes during the time. As well as modeling, the occurring of earthquake at an arbitrary time and its effects on the other variables of the city simulation by using appropriate mathematical tools. Using the system dynamics approach also brings us the ability to model the suggested policies by changing the key parameters and monitor them easily for comparing them on choosing the best strategy to get the purposed goal. (Ramezankhani & Najafiyazdi, 2008)

1.6.2 Case study

The case study method "explores a real-life, contemporary bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information… and reports a case description and case themes" (Creswell, 2013, p. 97). It is not aimed to analyze cases, but it is a good way to define cases and to explore a setting in order to understand it (Cousin, 2005). The case study strategy has a considerable ability to generate answers to the questions "what and how" (Lewis et al., p.139).

A single case may be used for a unique or a critical case or even for the opportunity to analyze a new phenomenon. Multiple cases often used when there is a need to generalize – as large degree as possible – the findings relate to the researcher position in respect to the unit of analysis (Vincenzo, 2016, p.30). Case study research strategy seems to diminish the comparability and the replicability of the findings because a single unit seems unable to provide a large degree of generalizability. The benefits of the case study method lie in its ability to open the way for discoveries (Shaughnessy & Zechmeister, 1985), indeed research based on case study aims to investigate specific issues. This type of strategy provides empirical control regarding the validity of a given theory. "A well-constructed case study strategy allows to challenge an existing theory and also provide a source of new research questions" (Lewis et al., 2007, p.140). A single case study "can easily serve as the breeding ground for insights and even hypotheses that may be pursued in subsequent studies" (Lune & Berg, 2016).

Table 1.2 Research methods used for research questions and objectives

Research Questions	Research Objectives	Research method
What is collaborative governance in post-disaster reconstruction?	Define collaborative governance in post-disaster reconstruction.	Literature review
Who are the key stakeholders in collaborative governance?	Identify the key stakeholders in collaborative governance.	Multiple case studies
How do the key stakeholders in collaborative governance relate to each other?	Recognize the collaboration between key stakeholders.	
What are the main outcomes and drivers of the collaborative governance in post-disaster reconstruction?	Produce a DPM framework which describes the main outcomes and drivers of the collaborative governance in post-disaster reconstruction.	System dynamics modelling
What are the interactions and feedback loops among these factors?	Build causal loop diagrams and system dynamics model to explicate the interactions and feedback loops among these factors.	
How to intervene these interactions and feedback loops in order to obtain sustainable post-disaster reconstruction?	Conducting policy analysis of this system dynamics model to provide practical suggestions for post-disaster reconstruction practitioners to enhance the collaborative governance and undertake reconstruction and recovery activities better.	

Does collaborative governance in post-disaster reconstruction work better than traditional mode?	Applying the general system dynamics model to a practical case.	Single case study& System dynamics modelling

This study is based on qualitative material and therefore secondary sources. This includes scientific articles, case studies and other literature. The research methods used to answer the research questions and meet the research objectives of this study are presented in table 1.2.

1.7 Scope of the study

This study is designed to understand how collaborative governance works in post-disaster reconstruction from an outcome-based perspective. Therefore, the intent of this study is to exclusively address the response actions that were taken by main stakeholders after the public emergency happened. This study focusses on the implementation of collaborative governance in post-disaster reconstruction activities using case studies in 2011 Gujurat Earthquake, 2003 Bam Earthquake, 2004 Indian Earthquake and Tsunami, 2005 Hurricanes Katrina, 2008 Wenchuan Earthquake, 2010 Haiti Earthquake, 2010-2011 Canterbury Earthquakes, 2011 Tohoku Earthquake and Tsunami, and 2015 Gorkha Earthquake. Qualitative and quantitative data of these cases was obtained from the current publication to build the DPM framework and conduct system dynamics modelling.

1.8 Contribution of the research project

This study aims to provide contributions both at a conceptual and a managerial level. At the first level, as it explores the collaborative governance in post-disaster reconstruction from an outcome-based perspective, this research contributes to knowledge by addressing a quantitative approach to answer how current reconstruction practices can be improved through collaborative governance. The DPM and SD modelling effectively illustrates the role played by each stakeholder and their interactions in the post-disaster reconstruction. This is important since there is limited similar work in the current literature. SD modelling has been applied to illustrate the importance of collaborative governance in post-disaster reconstruction in quantitative terms. To the best of the author's knowledge, there have been no similar studies to date. This research has extended the application of mixed methods (multiple case studies, single case study, DPM) in the area of collaborative governance which hitherto has been dominated in prevalence by qualitative research.

From a managerial point of view, the suggested framework and system dynamics modelling outline the key outcomes and performance drivers affecting the collaborative governance in post-disaster reconstruction. Using the SD approach allowed us to build a simulation model to be used by decision makers to test alternative policies and assess results based on key performance indicators. The findings based on different research methods, have complemented each other, and have lent better insight to the research topic. This represents a contribution for the public decision makers on how to improve system success and enhance its resilience. It also raises the important role of collaborative collaboration between participants in improving post-disaster reconstruction.

1.9 Thesis Structure

There are total six chapters in this doctoral thesis (Figure 1.6).

Chapter 1 illustrates the research background, research questions and objectives, and research methodology. It aims to give an orientation to the research design.

Chapter 2 reviews important pieces of the existing body of literature in the field of post-disaster reconstruction and collaborative governance. It analyzes the transformation from traditional manage mode to collaborative governance mode in post-disaster reconstruction practice. The chapter also illustrates how these paradigm shifts have affected the outcomes of post-disaster reconstruction activities in the long-term.

Chapter 3 argues how collaborative governance helps to improve the post-disaster reconstruction practice through applying a dynamic performance management framework. This chapter introduces the dynamic complexity which involves the key stakeholders (such as the government, profit organizations, non-profit organizations and the public) in the collaborative governance of post-disaster reconstruction. Based on the study of ten huge disasters since 2000, chapter 3 depicts the dynamic performance management framework and explains the relationship between output and outcome, presents performance measures and offers to decision-makers policy insights.

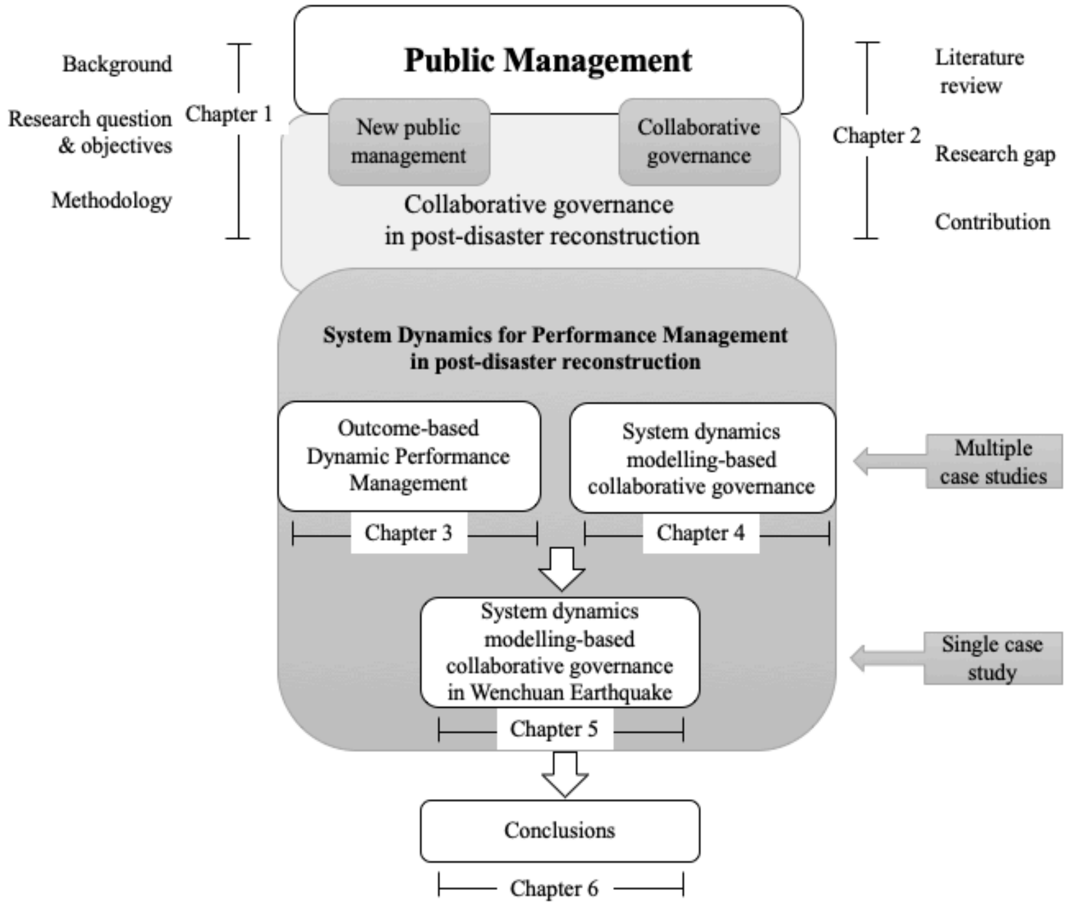


Figure 1.4 Overview of the research's layout and thesis' structure

Chapter 4 presents a system dynamics model to identify the key factors impacting on the outcomes of collaborative governance in post-disaster reconstruction based on the DPM framework in Chapter 3. The chapter goes through the model in detail, then it comments the policies by presenting simulation outputs. At last, model validation and policy analysis conclude the chapter.

Chapter 5 adopts the DPM framework and the general system dynamics model of the collaborative governance in post-disaster reconstruction to a real post-disaster reconstruction case – Wenchuan earthquake. It presents a system dynamics model to identify the key factors impacting on the outcomes of collaborative governance in post-disaster reconstruction based on the Wenchuan Earthquake case. The chapter also analyzes the special “Paired Assistance Policy” mode of collaborative governance and discusses the policies by presenting simulation results.

Chapter 6 summarizes main findings of the thesis.

Chapter 2 Review of the literature

2.1 Introduction

A disaster can emerge at anytime and anywhere in the world. Throughout history, humans have faced various disasters, the characters and scales of those confronted by modern society demonstrate drastic changes. The frequency of disasters is increasing, and the damage they cause is growing significantly. Disasters are one crucial part of community's crises with an annual average of 354 events, more than 68,000 killed per year, and about 210 million people affected annually (Annual Disaster Statistical Review, 2017). The increasing frequency and magnitude of disaster events in recent times and the resulting devastation have led to a greater focus on how to improve the efficiency and effectiveness of post-disaster reconstruction activities (Lloyd-Jones, 2006). Researchers such as Boano (2009), Khasalamwa (2009) and Ozcevik et al. (2009) proposed that the reconstruction phase should be used not only to restore communities to their pre-disaster states, but to take the opportunity to create safer, more sustainable and resilient communities. Such an approach is in line with the theory of "Build Back Better (BBB)" proposed by James Lee Witt Associates (2005) and Clinton (2006). How to improve the outcomes of post-disaster reconstruction represents a challenge for both researchers and practitioners.

For the over two decades, Collaborative Governance (CG) focused on how to solve "wicked" problems. Wicked problems are defined as problems which are complex, unpredictable, open ended, or intractable (Rittle & Wibber,1973; Head & Alford, 2015). They are difficult to face by a single organization because of resources limitation in the organizational, financial, and administrative capacity required to address complex and multifaceted phenomena effectively, such as disasters (Kapucu, 2010; Boin et al., 2016). Due to the catastrophic effects of disasters, that are beyond the scope of any single organization or sector, CG can be applied to manage disasters properly. Therefore, collaboration among public, private organizations, non-profit organization and the public has been emphasized recently in disaster management.

Some scholars explicitly embraced a multidisciplinary approach on studying collaborative governance, including political science (e.g., Ansell & Gash, 2008; Dryzek, 1990, 2010), public administration (e.g., Bingham et al., 2008; Emerson et al., 2012), public management (e.g., Agranoff & McGuire, 2003), planning (e.g., Forester, 1999; Innes & Booher, 2003; Margerum, 2011), conflict resolution (e.g., Costantino & Merchant, 1996), and environmental studies (e.g., Koontz & Johnson, 2004; Scholz & Stiftel, 2005; Susskind et al., 2010).

However, the growth of research on collaboration in disaster management has outpaced scholarship—researchers, practitioners, and students are working hard to understand how such systems emerge, what makes them work and whether they are producing their intended effects (Andrews & Entwistle, 2010). It has exposed the limitations of current analysis because such collaboration comprises various structures. Depending on the relationships among different multi-stakeholders (e.g., government, profit and non-profit organizations, and the public), the characteristics of the collaboration (e.g., goals, power, level of involvement, and strategies) necessarily vary. In addition, the performance of the collaboration may vary depending on the characteristics (e.g., natural disasters, human-made disasters or policy planning, execution, and assessment) of the work performed by the participants of the disaster and emergency sector. Performance management of collaborative governance in disaster management is still subject to future study.

In order to contribute to this field of research, this chapter offers a systematic literature review. The main purposes of Chapter 2 are to answer the following questions: What’s disaster and disaster management? What's post-disaster reconstruction? Why is it worthy of discussion? What's collaboration governance? Why is it important to study? How does collaboration governance fit in the post-disaster reconstruction? What are the limitations of the current study?

This chapter will try to offer answers to the above questions investigating the literature on post-disaster reconstruction and collaborative governance. Such an analysis will also allow us to draw preliminary insights and limitations of this research.

2.2 Disaster management

2.2.1 Disaster

As introduced in Chapter 1, disaster is an evolving concept. It has different sources and categories of definitions, ranging from applied sectors to social sciences. Prince (1920) is generally credited with conducting the first systematic disaster study, although issues of definition and context awaited the introduction offered by Carr (1932). After that, a number of formal definitions from many perspectives appear in the literature (Drabek, 1986; Quarantelli, 1987). Three collections of theory-based definitions can be identified for defining disaster: the classical period, the hazards-disaster tradition, and, most recently, the social phenomena (Perry, 2018). This session mainly traces disaster definitions devised by social scientists, thereby elucidating the evolution of scholarly thinking and the elements of the conceptualization.

The classical period can be associated with the end of World War II and closes with the publication of Fritz' definition in 1961. In this period, most of the studies referred to impact or threat of an agent and focused on social disruption. Killian (1954, p. 67) proposed that disasters are disruptions of the social order producing physical destruction and death. At the same time, Wallace (1956, p. 1) characterized disasters as "extreme situations" that involve not just impact, but also the threat of "an interruption of normally effective procedures for reducing certain tensions, together with a dramatic increase in tensions." Charles Fritz, moving in the same root, saw disasters as a phenomenon affecting an entire society (or some subdivisions), including both threat and actual impact, but at the same time emphasizing that "essential functions of the society [are] prevented" (1961, p. 655). Fritz's definition attempts to be more precise regarding the place of the social dimension adding "time and space" qualifications explicitly. Many researchers have adopted Fritz' definition verbatim or cited it in their studies (Perry & Lindell, 1997; Lowendahl, 2013).

Natural hazards perspectives have early and enduring links to human ecology (Burton et al., 1968; Kates, 1971). The classic statement of the hazards approach is found in the work of Burton et al. (1978), where a disaster is viewed as an extreme event that arises when a hazard agent intersects with a human use system. Consistent with this definition, Oliver (1980, p. 3) defined disaster as a part of the environmental process, but as a phenomenon that occurs when human systems intersect with the hazard creating major "human hardship with significant damage." While the principal thrust of hazards perspectives dealt with hazards from natural processes, it is possible to use a hazard view when the nature of the underlying threat is human-generated by specifying the underlying force or process (Perry, 2018).

Relatively recently, many scholars have incorporated more aspects of social relations as defining characteristics of disasters and moved away from conceptions that are depended heavily upon notions of physical destruction (Perry, 2018). Dynes (1998, p. 13) defines disaster as occasions when norms fail, causing a community to engage in extraordinary efforts "to protect and benefit some social resource." Rodriguez and Barnshaw (2006, p. 222) see a disaster as "human induced, socially constructed events that are part of the social processes that characterize societies." Wisner et al. (2012, p. 30) define a disaster as "a situation involving a natural hazard which has consequences in terms of damage, livelihoods, economic disruption and/or casualties" that outstrip the local capacity to cope. Wisner et al. (2014, p. 16) also point out that disasters are inherently social and that their occurrence both creates an opportunity for change simultaneously introducing stimulation for change. Each of these definitions moves toward an emphasis upon social contexts to varying degrees.

Besides these definitions devised by social scientists for theory-based uses, many scholars attempt to define disaster in other perspectives. For example, Keller and Al-Madhari (1996) applied arbitrary statistical benchmarks to define disasters. Thus, disasters were defined in terms of a threshold number of fatalities (10), damage costs (US $1 million) and a number of people evacuated (50). On the basis of this definition, they claim there were more than 6000 disasters since 1970, with 4 million deaths and widespread economic costs. This approach has the appeal of providing a solid, unambiguous foundation for defining disasters, and it is appropriate in the context of studies concerned about statistical issues, such as probabilistic prediction of frequency and magnitude of disasters. However, it loses sight of the qualitative factors referred to above, which are present in disaster situations irrespective of whether or not the fatality, damage cost and evacuation thresholds are reached (Wilks et al., 2013).

There's also scholar try to define disaster by comparing disaster with crises. Faulkner (2001) envisages a spectrum of events such as that depicted in Figure 2.1, with crises located at one extreme and disasters at the other. Crises and disasters epitomize chaos phenomena as it is described by such authors as Stengers and Prigogine (1985) and Faulkner and Russell (1997) in the tourism context. However, it is not always clear where to locate specific events along this continuum because, even in the case of natural disasters, the damage experienced is often partially attributable to human action. The damage caused by disaster depends on the climate, the geographical location and the type of the earth surface/degree of vulnerability and disasters adversely the mental, socio-economic, political and cultural state of the affected area in general (Rahman, 2012; Press & Hamilton, 1999; Ergünay, 1996).

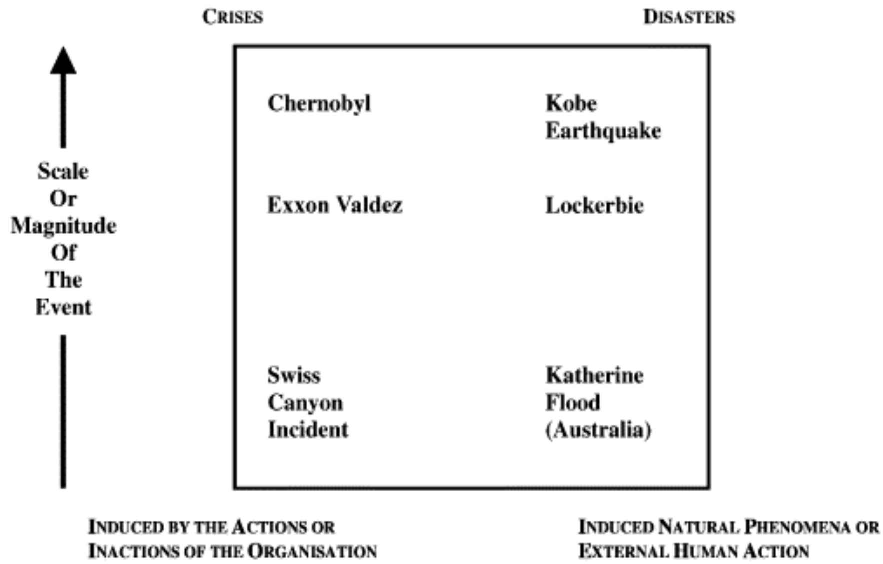


Figure 2.5 Crisis and disaster
(Faulkner, 2001)

It's not easy to find significant homogeneous content among a great number of definitions, devised at many different times by researchers from many different disciplines. However, the past decade has seen increasing agreement among researchers about the important features of disasters. A consensus definition of disaster could be "relatively sudden occasions when… the routines of collective social units are seriously disrupted and when unplanned courses of action" (Quarantelli, 2000, p. 682).

Besides the disaster definition, disaster classification is clearly another key issue to be addressed in order to improve study quality and to ensure comparability between different research. CRED and Munich Re-established a collaborative initiative, to implement a common “Disaster Category Classification and Peril Terminology for Operational Databases” in 2007. The classification differentiates between two generic disaster categories: natural and technological disasters. In their classification, technological disasters refer to hazards that stem from technological or industrial conditions. While natural disasters are extreme, sudden events caused by environmental factors that injure people and damage property. The natural disaster category is divided into six disaster groups (geophysical, meteorological, hydrological, climatological, extraterrestrial and biological), each of which is further divided into sub-groups, as shown in Figure 2.2.

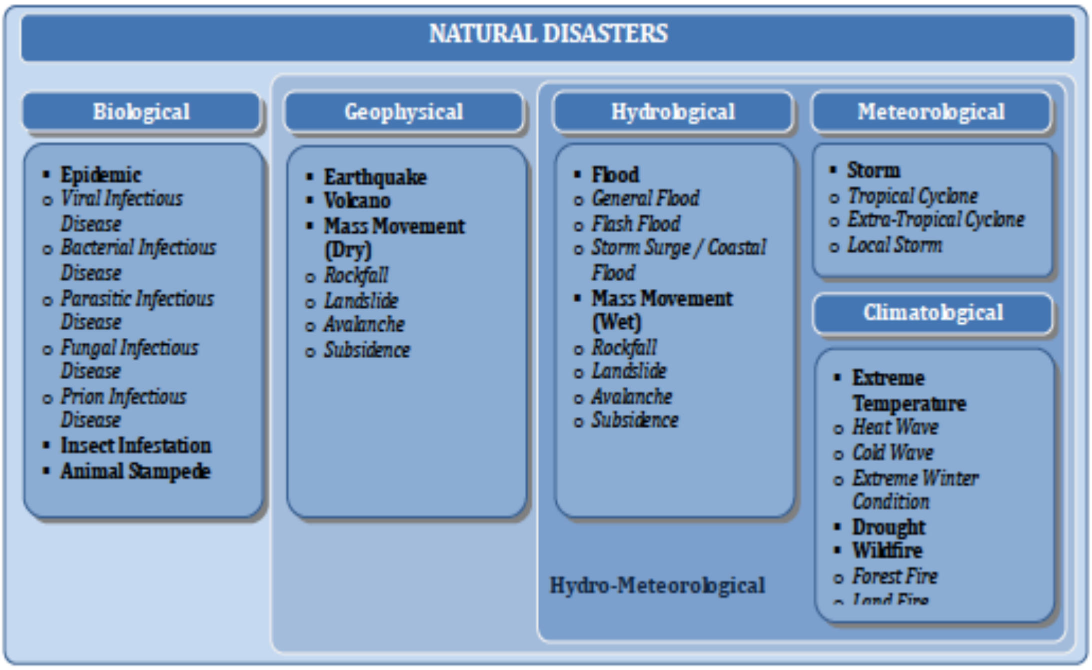


Figure 2.6 Natural disaster classification
(Below et al., 2009)

While the definition of disaster may vary from scholars, there are many things in common that are stressed by them. The disaster discussed in this paper is based on the concept of Quarantelli’s definition. Specially, two key defining features or essential dimensions are addressed: (1) publicity, which indicates that a disaster event affects not only the individual’s or small groups’ interests but also large-scale public interest; and (2) social disruption, which suggests that a disaster threatens or harms the life, property, public health or social security of the public. No matter what kind of emergency, it could change the existing state of a system. Human intervention is needed to restore the system to its original state or make the system achieve a better state.

2.2.2 Disaster management

Disaster management is defined as “a process or strategy that is implemented when any type of catastrophic event takes place” (Caymaz et al., 2013). In some studies, it is also described as disaster recovery management; the process may be initiated when anything threatens the normal operations or puts the lives of human beings at risk (Kale & Kutemate, 2011).

Disaster management is commonly represented by four phases: mitigation, preparedness, response and recovery (McLoughlin, 1985). The mitigation, as the initial phase of disaster management, is related to activities to reduce or eliminate potential long-term risk to people and property from disasters. Because it is not possible to mitigate completely against every disaster, the preparedness phase aims to build the disaster management function to respond effectively to an emergency. The key task of a disaster response is conducting rapid relief action (supplying emergency food, water, medicine, shelter, etc.) to minimize and save lives and property in the affected areas. The recovery stage usually involves long-term activities to restitute communities so that individuals, business, and governments can return to their normal function. The four terms have been widely used by policy-makers, practitioners, trainers, educators, and researchers.

Officials and scholars have used the disaster management cycle for the past 30 years to explain and manage the impacts of the activities that are carried out after disasters. Current disaster cycle management theory (Alexander, 2014; Carter, 2008; Quarantelli, 1998) makes clear that disaster management involves several phases: a relatively short emergency action and emergency response phase, a relatively long recovery and reconstruction phase, and an enduring mitigation and preparedness phase (Figure 2.3).

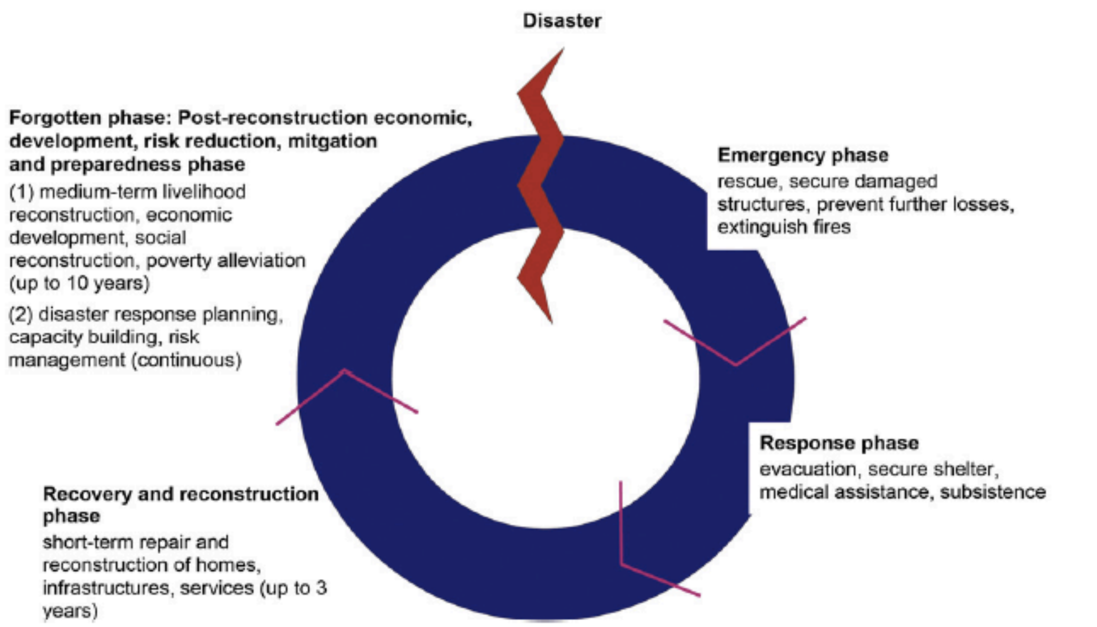


Figure 2.3 The disaster management cycle
(Dunford & Li, 2011)

Previous losses experienced in recurring disasters have led to a paradigm shift from "a traditional relief approach to disaster preparedness". This comprehensive approach recognizes that disaster mitigation has the highest effectiveness at the community level, where specific needs are met (Rahman, 2012). Thus, an efficient disaster management system becomes mandatory in order to mitigate recurring losses and manage the disaster in a successful manner. The challenges of recovery from disasters arising from natural hazards will be with us for the foreseeable future, and the demands for effective post-disaster reconstruction may, in fact, be increasing.

2.3 Post-disaster reconstruction

After the initial post-disaster response activities during the emergency and restoration periods, it is important to move quickly to the reconstruction and long-term recovery phase in order to restore a sense of normality in affected communities as soon as possible. Post-disaster reconstruction is a process with the potential for creating a resilient built environment or for generating further vulnerabilities to the disaster-affected communities. Lewis (2003) and Kijewski-Correa and Taflanidis (2012) noted that the reconstruction and recovery period following a disaster poses an opportunity to address and rectify vulnerability issues found in communities. Oliver-Smith (1991) advocated that the success of post-disaster reconstruction is much more than a matter of delivering and constructing houses and towns. It refers, indeed, how it is done and what or how much, is carried out.

Drabek and Hoetmer (1990) define disaster recovery and reconstruction as a qualitative improvement of community life; it usually includes the rebuilding of infrastructure and damaged structures, evaluation of codes and land use regulations, and adoption and implementation of hazard mitigation measures. According to the National Governor's Association (NGA) (2007) "recovery is defined as the process of restoring a community to pre-disaster conditions" and "[i]t is the final phase of managing an emergency and continues until all systems return to normal or near normal. Recovery is a longer and more complex process than response, and it can take years until the entire disaster area is completely redeveloped, either as it was in the past or for entirely new purposes that are more resistant to disasters".

Waugh and Streib (2006) suggest that recent catastrophic disasters have changed the way long-term recovery was initially viewed. Its increased importance is reflected through an enhanced emphasis on pre-disaster recovery planning, in the overall emergency planning efforts. There has also been more emphasis in the effort to "link disaster recovery to economic development and to deal with the long-term social and economic problems exacerbated by disasters" which makes a recovery a long, thoughtful process, rather than a process that advocates quick fixes. Comfort et al. (2010) argue that disaster recovery is not a regular emergency management function since non-traditional players such as housing agencies, public works, urban planners, and a myriad of private companies dealing with infrastructure development takes a front seat in recovery efforts. This makes the job of coordination and collaboration certainly more challenging but necessary.

Even if a number of academics and practitioners have been engaged in defining a set of cross-cutting challenges that face post-disaster reconstruction stakeholders. The issues such as disaster mitigation (Reddy, 2000; Schilderman, 2004), cultural sensitivity (Barenstein & Pittet, 2007), reconstruction financing (Comerio, 1997; Freeman, 2004), and environmental sustainability (Chang et al., 2010) have been identified as inherent in a post-disaster reconstruction process. Research on post-disaster reconstruction is a relatively new topic with rapid development potential. In order to analyze trends and patterns in current literature, inspired by previous comprehensive works (Ke et al., 2009; Yi & Yang, 2014), this research conducts a study of a three-round literature review of PDR papers published from 2002 to 2019. Publication coverage and research focus were identified among a range of criteria (Figure 2.4). To ensure no papers with high relevancy are left out, this research is conducted to search PDR-related papers published by all journals.

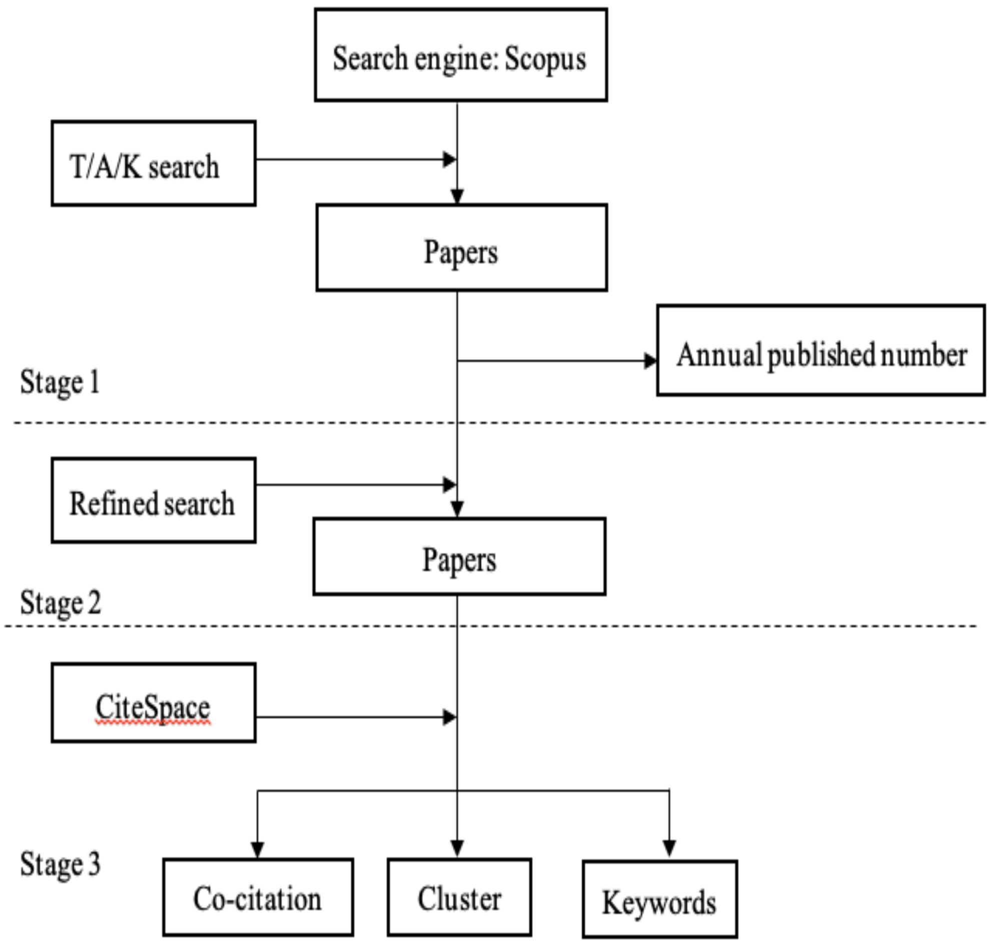


Figure 2.7 The research framework for post-disaster reconstruction
(adapted from Yang & Yi, 2014)

Scopus is chosen for its well recognised wide and well-recognised content coverage, from global as well as local peer-reviewed journals. Scopus is believed to have better performance than other engines such as PubMed, Web of Science, and Google Scholar, in terms of coverage and accuracy (Falagas et al., 2008). It is also popular among construction researchers (Ke et al., 2009, Yuan & Shen, 2011). In the subject areas of both “Physical Sciences” and “Social Sciences”, and with the document type of “article or review”, post disaster reconstruction, reconstruction after disaster, post disaster recovery, recovery after reconstruction, post disaster rebuilding and other relative keywords were included in the initial search to identify papers. The complete search code is listed as follows:

TITLE-ABS-KEY (post AND disaster AND reconstruction) OR TITLE-ABS-KEY (reconstruction AND after AND disaster) OR TITLE-ABS-KEY (post AND disaster AND recovery) OR TITLE-ABS-KEY (recovery AND after AND disaster) OR TITLE-ABS-KEY (post AND disaster AND rebuilding) OR TITLE-ABS-KEY (rebuilding AND after AND disaster) OR TITLE-ABS-KEY (post AND disaster AND redevelopment) OR TITLE-ABS-KEY (redevelopment AND after AND disaster) AND DOCTYPE (ar OR re) AND SUBJAREA (arts OR busi OR psyc OR heal OR envi OR engi OR deci OR econ) AND PUBYEAR > 2001 AND PUBYEAR < 2020

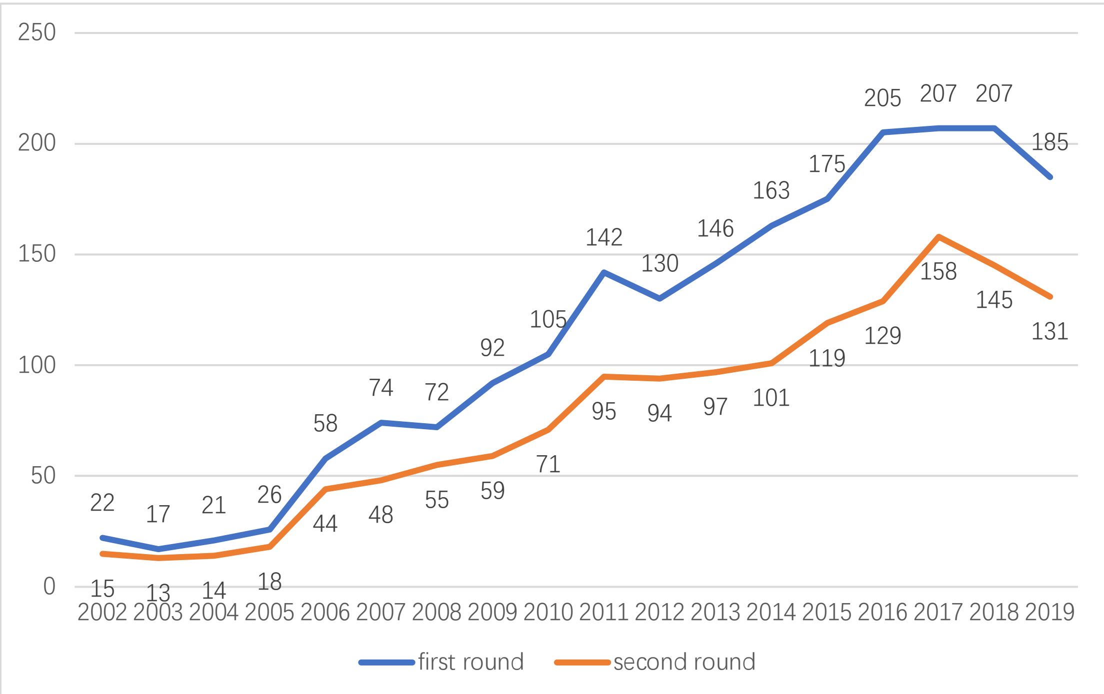


Figure 2.8 Number of PDR papers published between 2002 and 2019
(until 2th, September, 2019)

Round 1 of the search through Scopus yielded 2047 papers. The progression of papers published related to post-disaster reconstruction is shown in Figure 2.5. The number of papers each year had shot up tenfold from 22 in 2002 to 207 in 2018. This trend shows that PDR as a research topic, has received increasing attention at recent 20 years. A sharp growth in number since 2005 showed up, perhaps in response to the several deadliest natural disasters after this year. Such as Indian Ocean Earthquake and Tsunami in 2004, Kashmir Earthquake in 2005, Wenchuan Earthquake in 2008, Cyclone Nargis 2008, Haiti Earthquake in 2010 and Tohoku Earthquake and Tsunami in 2010-2011. According to the growth curve of post-disaster reconstruction, three stages can be identified as follows:

(1) Sprout stage (2002-2004). The annual number of articles published prior to 2005 was below 30. Although some scholars did research on reconstruction of cities (Huang & Min, 2002), rebuilding communities (Hodgson, 2004) and economic recovery (Beacham & McManus, 2004), most articles presented an extensive analysis of the impact of disasters on city and people.

(2) Development stage (2005-2015). In this stage, the number of articles has been researched over 100 each year. Post-disaster construction issues have become one of the most significant concerns among policy-makers, related scientists, international organizations, and national organizations because of the frequent occurrence of disasters. Many foundational theories and empirical research on post-disaster reconstruction had been put forward (Nakamura et al., 2017; Lyons, 2009). In addition, more new conceptions such as resilience and vulnerability were introduced in this field. For example, Norris et al. (2008) examined the notion that resilience may be best understood and measured as one member of a set of trajectories that may follow exposure to trauma or severe stress.

(3) Maturity stage (2016-now). Since 2016, the annual number of publishes articles published articles has started to stabilize around 200. The literature in this phase has still focused on several topics ranging from post-disaster housing recovery (Enshassi et al., 2017) to the reconstruction of property rights (Brown, 2018), and it has concentrated on different thematic areas, including urban planning (Zhao et al., 2017), capacity reconstruction (Tagliacozzo, 2016), and health perspectives (Powell, 2019). A new trend is that the studies has turned to the participant of relevant stakeholders in post-

disaster reconstruction and their interactions such as collaborative network (Tang, 2019).

Table 2.3 Top 10 journals that produced targeted papers

Ranking	Journal Title	Category	No. of papers
1	Natural Hazards	Natural hazards	95
2	Disaster Prevention and Management: An International Journal	Environmental management/Environment	49
3	Environmental Hazards	Human and policy dimensions of hazards	31
4	Sustainability Switzerland	Sustainability and sustainable development	30
5	International Journal of Disaster Resilience in the Built Environment	Built environment	26
6	Australian Journal of Emergency Management	Emergency management	23
7	Natural Hazards Review	Natural disaster	21
8	Disaster Prevention and Management	Disaster prevention and management	19
9	Wit Transactions on Ecology and the Environment	Computational methods and experimental measurements	18
10	International Journal of Environment Research and Public Health	Environmental sciences and engineering, public health, environmental health	17
	Total		329

Based on the literature database obtained in the first round, in the second round, this research narrows down the research topic to subject areas of "*social science*", "*environment science*", "*business management and accounting*", "*arts and humanities*", and "*decision science*". This process of selection is due to the requirement of focusing on the topic of our research. Round 2 of the search through Scopus yielded 1046 papers. The annual number of articles published in these fields is consistent with the development trend in round 1 (Figure 2.5). The top 10 journals with papers published are listed in Table 2.1. The Natural Hazard is the leading specialist journal in post-disaster reconstruction with publishing 94 articles during the period of 2002-2019. It is far ahead of other journals. Then the second most prolific journals are *Disaster*

Prevention and Management: An International Journal (48), followed by *Environmental Hazards* (31), *Sustainability Switzerland* (30), *International Journal of Disaster Resilience in the Built Environment* (25), and *Australian Journal of Emergency Management* (23).

In the third round, the CiteSpace software is used to analyze the co-citation, keywords and cluster analysis. A visualization of the document co-citation network, a time zone view of keywords and a visualization of the cluster analysis are conducted in order to explore research direction more intensely.

Co-citation is defined as the frequency with which two items of earlier literature are cited together by the later literature (Small, 1973). It is a useful tool for mapping the intellectual structure of science as co-citation patterns viewed over a period of years can provide clues to understanding the mechanism of speciality development. Besides, co-citation analysis is more reliable to provide important insights into knowledge domains compared with citation-only analysis because it would risk excluding articles that hold promise (Mustafee et al., 2014). The co-citation network of a subject is first derived using graph-theoretical approaches as implemented in CiteSpace (Chen, 2004). Network nodes are subsequently clustered by using the "expectation maximization" algorithm based on a series of attributes, including citation frequency, betweenness centrality (BC), the first author of the article, the year of publication, the source of the publication, and the half-life of the article (Chen, 2004; Dempster et al., 1977). The Document Co-citation Network (DCN) is generated in this study to explore the underlying clusters that have high article co-citation counts associated with them, as well as the most cited works to find the most influential points (based on the co-citations they received) in the knowledge structure.

The following parameters in CiteSpace were used: (1) Time slice from 2002 to 2019; (2) Term source = title/abstract/author keywords/keywords plus; (3) Node type = cited reference; (4) Pruning = pathfinder/pruning the merged network. A mapping of co-citation network is got after running CiteSpace (Figure 2.6). The analysis is also performed to identify the most well-recognized studies based on the number of citations. The top 6 most-cited studies include: Aldrich (2012)'s research on integrating the concepts of networks and personal contacts into understanding how social resources influence post-disaster reconstruction structural equation modelling (citation 21);

Chang (2010)'s study on assessing empirical patterns of urban disaster recovery through the use of statistical indicators (citation 12); Tierney (2012)'s study on factors that contribute to effective governance and on other topics, such as the extent to which governance approach contribute to long-term sustainability(citation 6); Norris et al. (2008)'s study presents a theory of resilience that encompasses contemporary understandings of stress, adaptation, wellness, and resource dynamics (citation 5); Dunford and Li (2011)'s study on examining the progress made in the first year of reconstruction in rural Wenchuan and the challenges that remain by focusing on the relationships between reconstruction, disaster mitigation and poverty alleviation (citation 5); Peacock et al. (2014)'s research on reporting empirical work on housing units along with neighborhood sociodemographic data from 1992′s Hurricane Andrew in Miami-Dade (FL) and 2008's Hurricane Ike in Galveston (TX) to assess long-term trends in housing recovery.

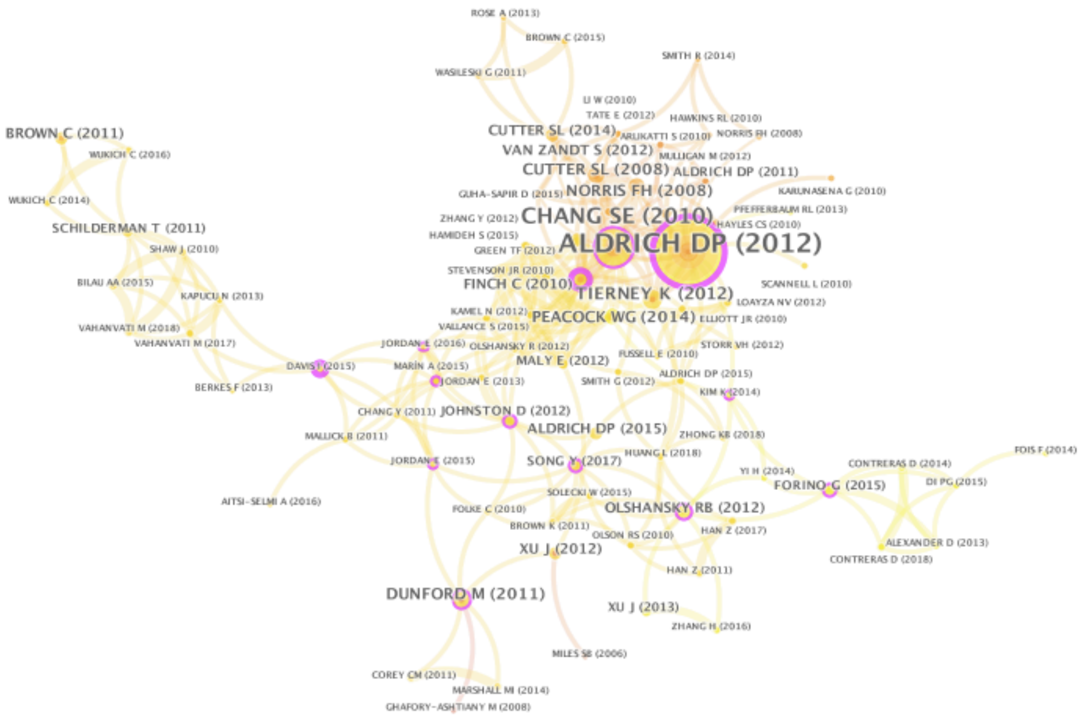


Figure 2.9 Mapping of co-citation network

As shown in Table 2.2, the top 5 keywords with the highest frequency are disaster management (136), followed by disaster (83), natural disaster (58), reconstruction (49), recovery (44).

Table 2.4 Keywords according to frequency related to post-disaster reconstruction

Ranking	Keyword	Frequency	Centrality
1	disaster management	136	0.20
2	disaster	83	0.30
3	natural disaster	58	0.19
4	reconstruction	49	0.11
5	recovery	44	0,08

Figure 2.7 shows the keywords clusters according to their frequency in the targeted post-disaster literature. In total, 6 keyword major clusters are identified, including public participation, affecting earthquake recovery, building resilience, mental health recovery, medium-term recovery process and federal resource distribution. The largest cluster (cluster #0) includes 38 keywords and a Mean Silhouette value of 0.712. This cluster is labelled influence by LSI algorithm, public participation by LLR algorithm, and recovery, national post-disaster plan, reconstruction planning, field research by MI algorithm. This hotspot focuses on evaluating the post-disaster reconstruction practice.

The second largest cluster (cluster #1) includes 26 keywords and a Mean Silhouette value of 0.825. This cluster is labelled Indonesia by LSI algorithm, affecting earthquake recovery school by LLR algorithm, and yingxiu town, building damage, earthquake characteristic by MI algorithm. This hotspot focuses on the damages caused by disasters and factors affecting their reconstruction.

The third largest cluster (cluster #2) includes 27 keywords with Mean Silhouette value of 0.744. This cluster is labelled resilience by LSI algorithm, building resilience by LLR algorithm, and resilience people, resilience dwelling, people-centered reconstruction by MI algorithm. This hotspot focuses on improving resilience.

The fourth largest cluster (cluster #3) includes 26 keywords and a Mean Silhouette value of 0.93. This cluster is labelled case study by LSI algorithm, mental health recovery by LLR algorithm, and health consequence, syndromic surveillance database, armed conflict by MI algorithm. This hotspot focuses on mental health care in the post-disaster process.

Figure 2.10 Mapping of keyword clusters

The fifth largest cluster (cluster #4) includes 24 keywords and a Mean Silhouette value of 0.835. This cluster is labelled earthquake by LSI algorithm, medium-term recovery process by LLR algorithm, and field research, post-disaster setting, yingxiu town, building damage by MI algorithm. This hotspot focuses on the field study of medium-term reconstruction.

The sixth largest cluster (cluster #5) includes 21 keywords and a Mean Silhouette value of 0.736. This cluster is labeled hurricane by LLR algorithm, federal resource distribution by LLR algorithm, and community adaption, hurricane sandy damage, field research, yingxiu town by MI algorithm. This hotspot focuses on collaborative resource allocation in post-disaster reconstruction.

The analysis of keyword co-occurrence is an effective way to show emerging trends and track topics of research over time because keywords provide a concise and precise high-level summarization of a document. The changes in research topics have become an important research issue, which can help researchers to gain deeper insights into the development of a particular research field. Keyword cooccurrence analysis based on CiteSpace contains two main procedures: one is to extract the keywords, then separate and classify them in order to calculate the frequency; the other is to acquire keyword co-occurrence matrix used for the analysis of keyword co-occurrence (Chen, 2004; Chen, 2006).

The technique of keyword co-occurrence analysis is used in this paper to monitor development trends in the field of climate change and tourism and project future research directions. This map of timezone view together with the curve linking these purple nodes indicates the major knowledge structure extending from disaster management and earthquake to human, mental health, female and controlled study. These themes are all associated with people dimension and may become future directions. In a deeper analysis, this research has identified current key nodes relatively many light links (i.e. yellow links). The color of links shows the time of co-appearance of two keywords; therefore, it can help to provide clues of future trends (Chen, 2004; Chen, 2006). Most of the nodes on the right site (i.e. new keywords) are derived from human, mental health, female and controlled study (see Figure 2.8). Hence, this study asserts that future research trends have a great chance to be developed based on these themes.

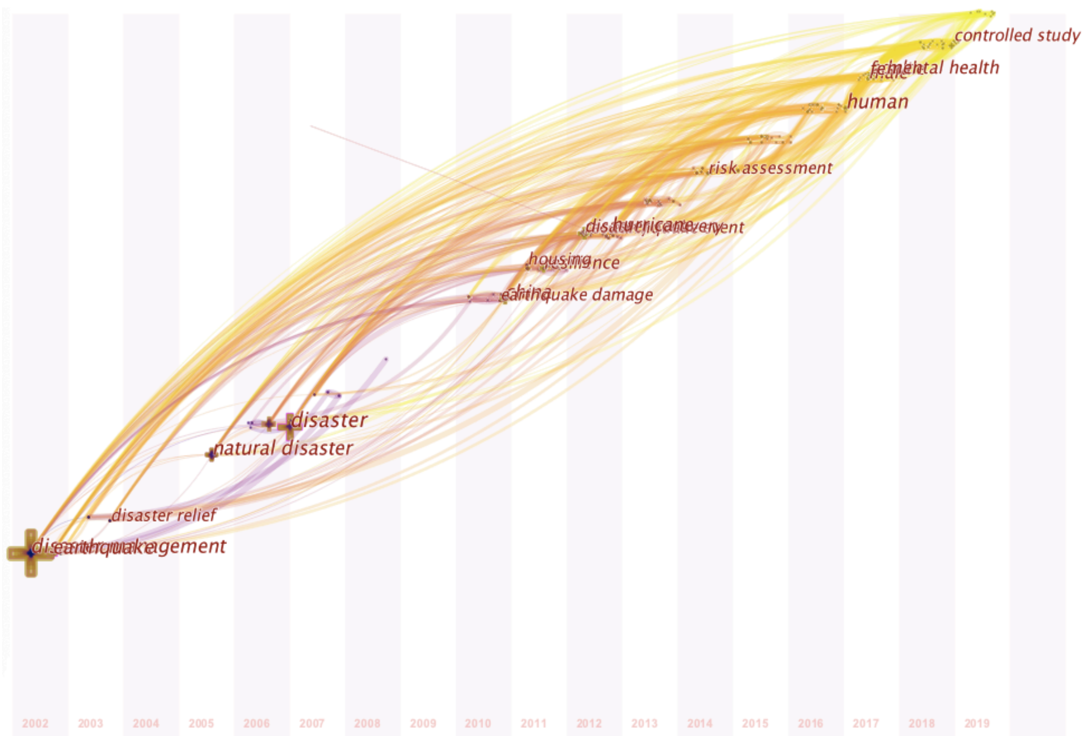


Figure 2.11 Mapping of keywords timezone view

This part constructs comprehensive knowledge maps of post-disaster reconstruction research, which provides an insight into medication literacy and valuable information for post-disaster researchers to understand the current study and identify new perspectives on post-disaster reconstruction. The above analysis results show that research on post-disaster reconstruction has developed rapidly in the last decades. The topics in post-disaster reconstruction study focused on the public participation from micro-level (i.e. social capital, SMEs, NGOs), measurement and assessment of post-disaster reconstruction practice, social properties of disaster reconstruction (i.e. mental health of disaster victims, disaster impacts on social-economic development). The reconstruction period and recovery phase need to be further studied and improved.

2.4 Collaborative governance

To advance the study and practice of collaborative governance, we need agreement on definitions of commonly used terms, beginning with the word “collaboration” and “governance.”

Collaboration as a way to solve complex societal problems is gaining interest across many scientific fields and disciplines. It means to co-labor, to achieve common goals, often working across boundaries and in multi-sector and multi-actor relationships. Collaboration is based on the value of reciprocity and can include the public. The term “collaboration” lacks a common lens or definition. Four examples from three different decades, which are widely cited today, are provided here for illustrative purposes. Gray (1989) defined interorganizational collaboration as an emergent process between interdependent organizational actors who negotiate the answers to shared concerns. Huxham (1993) writes that “collaborative advantage will be achieved when something unusually creative is produced—perhaps an objective is met—that no organization could have produced on its own and when each organization, through the collaboration, is able to achieve its own objectives better than it could alone. In some cases, it should also be possible to achieve some higher-level . . . objectives for society as a whole rather than just for the participating organizations”. In his later research, Huxham (1996) defined collaboration as “working in association with others for some form of mutual benefit”. Bardach (1998) defined collaboration as “any joint activity by two or more agencies working together that is intended to increase public value by their working together rather than separately”.

Most prior research on collaborative approaches focuses on two broad questions: (1) why actors choose to collaborate, and particularly why do they choose to collaborate with certain others, and (2) are collaborative approaches effective in solving the problems they are set out to address? Empirical research addressing the former question has revealed that there are many factors that shape actors’ motivations to engage in collaboration and with whom they prefer to collaborate with (Berardo and Lubell, 2016; Ingold & Fischer, 2014; Nowell & Steelman, 2015). Research in relation to the latter question has shown to be more problematic since what qualifies as a desired outcome for a collaborative initiative often varies from case to case, and thus defining effectiveness is difficult, ambiguous, and context dependent (Turrini et al., 2010).

Another critical component of the term collaborative governance is “governance.” Much research has been devoted to establishing a workable definition of governance that is bounded and falsifiable, yet comprehensive. Stoker (1998) argues governance as a baseline definition; it can be taken that governance refers to the rules and forms that guide collective decision-making. That the focus is on decision-making in the collective implies that governance is not about one individual making a decision but rather about groups of individuals or organizations or systems of organizations making decisions. Stoker (1998) identifies five propositions for describing key elements of what entails governance and its structures. These are: governance structures are comprised of both state and non-state actors; boundary spanning is a common practice for dealing with public issues; power dependencies and resource dependencies exist between different agencies and entities; the structures may be self-governed networks; structures rely on the capacity and power of non-state actors in order to achieve better governance outcomes. Along with these key principles identified in the literature, leadership is a pertinent element of collaborative and networked governance where public managers and leaders help to mobilize, facilitate, and implement collaborative and cooperative structures (Ansell & Gash, 2007; Kapucu, 2012; Moynihan, 2005) to achieve set goals and take responsibility to engage stakeholders in deliberative ways (Wallis & Gregory, 2009).

Lynn et al. (2001) construe governance broadly as "regimes of laws, rules, judicial decisions, and administrative practices that constrain, prescribe, and enable the provision of publicly supported goods and services." This definition provides room for traditional governmental structures as well as emerging forms of public/private decision-making bodies. Moynihan (2005) describes governance as a networked form of government that involves entities across sectors with different skills, expertise, and resources. It is a governance form that has become more popular with complex institutional structures and provides a distributed knowledge of agencies and sectors. Agranoff (2006, 2007) suggests that governance can take the form of less-binding relationships like coordination and cooperation to more formal relationships that involve mandated or formal partnerships. These descriptions of governance reflect the idea that the government plays the central role in engaging other sectors while some descriptions of governance, such as those by Rhodes (1996), focus on the states having a minimal role.

Based on the definition of collaboration and governance, collaborative governance is a form of governing where both public and private entities are involved in collective and consensus-oriented decision-making (Ansell & Gash, 2007; Emerson et al., 2012; Kapucu, 2012). It emphasizes collaboration which is beyond mere coordination and requires the achievement of shared goals and shared decision-making through both inter-organizational and cross-sector efforts and relationships (Agranoff & McGuire, 2003; Bardach, 1998; Bryson et al., 2006). Collaborative governance has a strong normative appeal, based on the assumption that inclusive and horizontally organized network approaches to increase effectiveness in addressing complex and cross-sectoral problems (Ansell & Gash, 2007; Kickert et al., 1997; Koppenjan & Klijn, 2004).

Connick and Innes (2003) define collaborative governance as including "representatives of all relevant interests." Ansell and Gash (2007) define collaborative governance as "A governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative and that aims to make or implement public policy or manage public programs or assets." This definition stresses six important criteria: (1) the forum is initiated by public agencies or institutions, (2) participants in the forum include nonstate actors, (3) participants engage directly in decision making and are not merely "consulted" by public agencies, (4) the forum is formally organized and meets collectively, (5) the forum aims to make decisions by consensus (even if consensus is not achieved in practice), and (6) the focus of collaboration is on public policy or public management. This is a more restrictive definition than is sometimes found in the literature. They also identify the difference between consultative techniques and collaborative techniques of engagement which reflect two-way communication and multilateral engagement and emphasize its importance in effective collaborative governance.

O'Leary and Bingham (2007) provide a nine-step process for building a collaborative governance structure with the aim of trying to prevent conflict through forethought and adaption to the needs of the collaborators, resource and power distribution, communication, context, and the degree of flexibility required for the collaboration to progress.

Emerson and Nabatchi (2015) put forward an integrative framework to define collaborative governance broadly as "The processes and structures of public policy decision making and management that engage people . . . across the boundaries of public agencies, levels of government, and/or the public, private, and civic spheres to carry out a public purpose that could not otherwise be accomplished." This definition parallels other definitions of collaborative governance but captures a wider range of emergent forms of cross-boundary collaboration, extending beyond the conventional focus on the public manager or the formal public sector, and also including some of the more traditional forms, such as interagency cooperation (e.g., Ansell & Gash, 2008; Bingham & O'Leary, 2008).

Sometimes scholars do not differentiate between collaborative public management, networks and collaborative governance (Kapucu et al. 2010). Like governance can take the form of cooperative exchange, coordinative or collaborative exchange between entities, networks can also have various forms. Brown and Keast (2003) describe cooperative networks to reflect informal and short-term relationships between entities, coordinative networks to depict joint working, decision-making and collective action for limited time action, and collaborative networks to emphasize more formal, long-term and sustainable relationships with a high level of inter-organizational trust and familiarity. However, Kapucu et al. (2009) suggest that although these terms are very similar and may follow similar characteristics and processes, in essence, they are fairly different. Collaborative governance has a broader meaning compared to collaborative public management which clearly focuses on managing localities and holds public agencies and their roles in the collaborative arrangement as central and essential. Collaborative governance, on the other hand, has a broader, global appeal that includes collaborative public management, networks and inter-organizational and inter-jurisdictional cooperation and collaboration.

For over two decades, emerging systems of collaborative governance have attracted the attention of scholars and practitioners in multiple disciplines, including political science (e.g., Ansell & Gash, 2008; Dryzek, 1990, 2010), public administration (e.g., Bingham & O'Leary, 2008; Emerson et al., 2012), public management (e.g., Agranoff & McGuire, 2003), planning (e.g., Forester, 1999; Innes & Booher, 2003; Margerum, 2011), conflict resolution (e.g., Costantino & Merchant, 1996; Susskind & McKearnen, 1999), and environmental studies (e.g., Koontz et al., 2004; Scholz & Stiftel, 2005; Susskind et al., 2010). Emerson and Nabatchi (2015) introduce the concept of a collaborative governance regime (CGR) shown in Figure 2.9, defined as "the particular mode of, or system for, public decision making in which cross-boundary collaboration represents the prevailing pattern of behavior and activity" (Emerson et al., 2012; Emerson & Nabatchi, 2015). Three performance levels (actions, outcomes, and adaptation) are addressed at three units of analysis (participant organizations, the CGR itself, and target goals), creating a performance matrix of nine critical dimensions of CGR productivity.

The concept of a CGR is a central feature in this framework. Emerson and Nabatchi (2015) use the term "regime" to encompass the particular mode of, or system for, public decision making in which cross-boundary collaboration represents the prevailing pattern of behaviour and activity. Crosby and Bryson (2005, p.51) also use this term in their work, drawing on Krasner's (1983, p.2) definition of the regime as "sets of implicit and explicit principles, rules, norms, and decision-making procedures around which actors' expectations converge in a given area." In this framework, the CGR is depicted by the middle box with the dashed lines and contains both the collaborative dynamics and collaborative actions. Together, collaborative dynamics and actions shape the overall quality and extent to which a CGR is developed and effective.

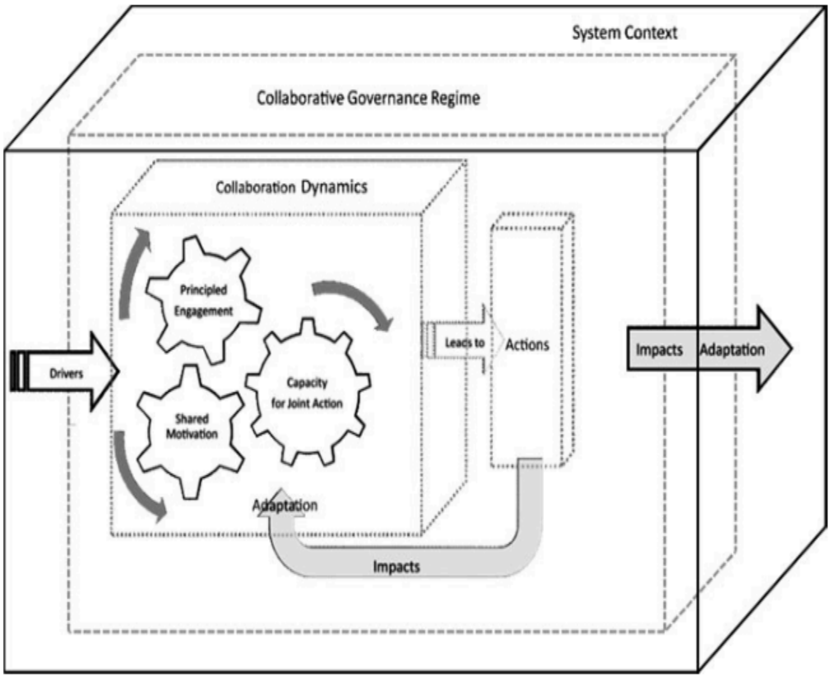


Figure 2.12 Collaborative governance regime
(Emerson et al., 2012)

Nonetheless, empirical evidence within the broad field of public management is building up and demonstrates that collaborative approaches can be effective in solving complex problems. But it is also shown that there is no guarantee that this will happen automatically, and again, the effectiveness in problem solving depends on the specific tasks at hand (Folke et al., 2005; Koontz & Thomas, 2006; Lubell et al., 2014; Scott, 2015). These insights are corroborated by the growing literature on collaborative responses to crises and disasters, which sheds light on the challenges involved in managing collaboration within multi-organizational networks under conditions of threat, urgency, and uncertainty (McGuire & Silvia, 2010; Moynihan, 2009; Waugh & Streib, 2006). While this literature generally acknowledges the role of interdependency as a key driver for collaboration, less attention has been devoted to assessing the nature of task interdependency, how it affects collaboration, and conditions for collective disaster response performance.

The literature on cross-boundary collaboration has identified several potential benefits, including improved coordination of activities, better leveraging and pooling of resources, increased social capital, enhanced conflict management (prevention, reduction, and resolution), better knowledge management (including generation, translation, and diffusion), increased risk-sharing in policy experimentation, and increased policy compliance (Agranoff, 2008; Agranoff & McGuire, 2003; Leach & Sabatier, 2005). Collaborative governance usually happens among several autonomous actors and over time, which means that outcomes must be measured at multiple levels and stages. These and other challenges have created real obstacles to the robust examination of collaborative performance.

2.5 Collaborative governance in post-disaster reconstruction

The increasing frequency of disaster events in recent times has led to a demand for improved post-disaster reconstruction and recovery efforts. Collaborative governance can be defined as a collective effort of the stakeholders in recovering from disasters. Collaborative networks are essential in emergency management and disaster response (Drabek & McEntire, 2002; Kapucu & Garayev 2013; Waugh & Streib, 2006). Collaborative emergency management aims to tackle the structural problems associated with traditionally rigid, less open command and control response and recovery systems (Birkland, 2007; Kapucu, 2006, 2008; Kapucu et al., 2010; Ward & Wamsley, 2007). According to Waugh and Streib (2006), "[w]hat we now call the new governance process forms the core of our national emergency response. Consensual processes are the rule". The field of emergency management has transformed from a top-down bureaucratic model to a more flexible network orientation that supports inter-organizational coordination, cooperation and collaboration.

The concept of governance based on the relationship among participants in post-disaster recovery has become an increasingly popular explanatory tool. After closely observing post-disaster recovery following a number of major disasters, Olshansky et al. (2012) proposed that such events simultaneously deplete both capital stocks and services, which in turn requires a multitude of complex rebuilding and societal activities to occur within a compressed period of time; one such activity is governance. Other scholars (Reiss, 2012; Smith & Birkland, 2012) suggest that multi-entity participation is the best way to address issues such as the insufficient capacity to solve problems;

excess demands for information and timely decisions from stakeholders; the greater need for organizational integration and coordination; and immediate demands for significant funding. Garnett and Moore (2010)—in their investigation of the long-term recovery and redevelopment efforts associated with eight catastrophic disaster events (including the September 11, 2001, terrorist attacks in the USA, Hurricane Katrina in 2005, and the 2010 Haiti earthquake)— found that both a bottom-up approach involving local people and a top-down approach incorporating a long-term vision for development from the central government is needed for disaster recovery.

For example, America has adopted a bottom-up approach appraising local people's views and priorities on how best to support their livelihoods within the programs developed in the aftermath of such events (Daly & Brassard, 2011; Moatty et al., 2017). The Whole Community approach has also recently been promoted by Federal Emergency Management Agency (FEMA). This is a philosophical approach to conducting better and improved emergency management by engaging the whole community (Edwards, 2013). This is an approach through which citizens, government agencies, private and nonprofit organizations, community leaders and practitioners collectively decide on ways to improve their communities in order to build resiliency and a strong social structure that improves emergency management (FEMA, 2011). The Whole Community approach followed during the preparedness and mitigation phase helps to improve response, and recovery stages of the emergency management cycle since partnerships and relationships built between community players and agencies have been developed, and local resources and capacity have been assessed as part of this approach (FEMA, 2011). When multi-jurisdictional and cross sector partnerships have been formed in a community, then functional and resource coordination and collaboration becomes easier in the phases of emergency management (Kapucu, 2012).

While in China, top-down approach, which emphasizes international organizations and national government actions at the detriment of local coping strategies is adopted. Tang (2019) argues that the approach to recovery following the Wenchuan Earthquake in China experienced a transformation from paired assistance under centralized political mobilization to collaborative networks. Based on an in-depth case study of the Shanghai–Dujiangyan Paired Assistance Policy, they find that recovery from the Wenchuan Earthquake can be demarcated and described in terms of three stages involving government-oriented project aid, contract-oriented industrial redevelopment, and network-oriented collaborative governance. Zhang and Kumaraswamy (2012) also propose a Public-Private-People Partnerships (4P) approach to deliver reconstruction projects. The 4P systems, developed on the base of PPP approach, involves key stakeholders that will contribute significantly and play critical roles in reconstruction, such as Non-Governmental Organizations (NGOs), local communities, professional groups, academia and media.

The above discussion on the participants, their interactions, and their participating effectiveness in post-disaster reconstruction has been well researched. However, such studies primarily address the performance of a single participant or interaction at a certain moment of post-disaster reconstruction. They lack long-term and continuous observation throughout the reconstruction process to understand how participants transform over the different stages of post-disaster reconstruction. Post-disaster reconstruction should not only be viewed in terms of the short-term restoration of infrastructure and public services; instead, more broadly, it must account for the long-term processes of restoring, rebuilding, and reshaping the physical, social, economic, and natural environment following the disaster.

2.6 Summary

In summary, post-disaster reconstruction is particularly critical for disaster management because it offers an opportunity to improve things on the ground. In other words, post-disaster reconstruction represents an opportunity to make things better than before. Unlike disaster relief effort, which is focused on meeting the most immediate needs in terms of medical treatment, food, shelter and basic services, post-disaster reconstruction emphasizes on effective and productive medium-term recovery and long-term reconstruction.

As a complex system and long-term process, post-disaster reconstruction requires multi-stakeholders to work in multi-disciplinary teams and with local partners and intermediaries in order to fulfil the requirement of very significant resources and a wide range of skills. Public managers who work collaboratively find themselves not solely as unitary leaders of unitary organizations. Instead, they often find themselves facilitating and operating in multiorganizational arrangements to solve problems that cannot be solved, or solved easily, by single organizations. Although collaborative public management has been investigated since a long time (Agranoff & McGuire, 2003; Hall & O'Toole, 2000, 2004; Hull & Hjern, 1987; O'Leary & Bingham, 2009), many changes emerged in the environment of public, private, and nonprofit organizations that have encouraged the growth of collaborative public management. As Bryson et al. (2006) note, "the point of creating . . . cross-sector collaboratives ought to be the production of 'public value' (Moore, 1995) that cannot be created by single sectors alone".

Restoration of the damaged physical, social, economic and environmental subsystems is a complex process. Reconstruction and recovery projects often focus on quick restoration of affected communities which can worsen existing vulnerabilities (Johnson et al., 2006, Lyons, 2009). Despite being pervasive and considered a good solution to manage post-disaster reconstruction and provide public services, collaborative governance needs to be investigated alongside its performance and structural and managerial characteristics. Addressing these topics is crucial not only for scholars in the field but also for the community at large.

To provide a better overview of collaborative governance in post-disaster reconstruction, this research summarizes a framework to conceptualize and understand its characteristics based on the literature review.

Participants/stakeholders

In the literature, a broad spectrum of stakeholders has been identified as important to the effective delivery of public outcomes. These include: citizens, service users or consumers, the business community, interest groups and stakeholders (Bryson, 2004). An initial step in activation is the identification of network participants (Lipnack & Stamps, 1994) whose skills and resources are required by the network (Agranoff & McGuire, 1999). Furthermore, the need for networks to identify stakeholders has been explicitly confirmed by Gray (1989). Therefore, in the process of post-disaster reconstruction, multiple stakeholders, including governmental, non-governmental, and community-based actors should be included.

Structure

Networks are believed to be more effective than a market or hierarchy when the problem at hand requires an adaptive and flexible approach due to inconsistent information or uncertain conditions existing, or when the knowledge and resources needed to address the issue spans boundaries (Provan & Lemaire, 2012). Collaborative governance adapts a horizontal network with less rigidity, more flexibility, and non-hierarchical structures. And the current research has shown that the way networks are created and led, in turn, is a matter of network leadership, which is successful to the extent resource management, trust-building, stakeholder-oriented approaches, shared understanding, and the like are successful (Silvia, 2011; Silvia & McGuire, 2010).

Process

Fung and Wright (2001) note that "participants will be much more likely to engage in earnest deliberation when alternatives to it—such as strategic domination or exit from the process altogether—are made less attractive by roughly balanced power." Ansell and Gash (2008) also defined collaborative governance as "consensus oriented," though pointed out that consensus is not always achieved. The goals are developed during interaction and decision-making processes, elected officeholders are part of the process or meta-governors.

Outcomes

Roger and Weber (2010) put forward there are three outcome categories of collaborative governance, including enhancing public agencies' programmatic effectiveness for existing mandates, building new systemic collaborative capacity through technology development and transfers, improving public problem-solving capacity by taking advantage of the opportunities provided in these collaborative arrangements to tie together and collectively manage interdependent problems and policies. In the post-disaster reconstruction, these outcomes can be thought of as long-term outcome with considering process outcome, policy outcome, management outcome of the post-disaster reconstruction practice.

Governance forms

In the past, post-disaster reconstruction is mainly managed by the government using direct interactions within organizations. The traditional management mode of post-disaster reconstruction activities has not been efficient and effective enough to build the disaster area back on time, on budget and with acceptable quality. Comparing with the traditional management mode, collaborative governance in post-disaster reconstruction is achieved in the form of cross-organizational interactions. Cross-organizational collaboration is when two organizations come together to work on a project or business activity (Weiss & Hughes, 2005). There might be several reasons behind the partnership, usually for the benefit of a specific project, but it includes a joining of resources to make the organizations stronger as a unit than they would be as an individual actor.

Coordination mechanisms

Previous studies have shown that more short-term relationships, the higher degree of top-down mechanisms and higher trust in relationships increase the bottom-up mechanisms in the network (e.g., Lucidarme et al., 2016; Markovic, 2017). The traditional management mode of post-disaster reconstruction relies on top-down hierarchical power control. Its collaboration was not equal in that respondents clearly perceived the municipalities to constitute the main organization. As a long-term activity, post-disaster reconstruction needs to build an equal collaboration based on mutual trust, mutual understanding, internal legitimacy and shared commitment. Collaborative governance could provide an environment to support all stakeholders directly take part in the decision-making process.

While governance tends to emphasize the horizontal relationships between governmental and other organizations, the traditional post-disaster reconstruction management can be considered an opposing paradigm to governance in many ways since it emphasizes central steering and political control where governance tends to emphasize the limits of central control. Table 2.3 summarizes some of the main difference between collaborative governance mode and traditional management mode in post-disaster construction.

However, the current study has limitations as follows:

Firstly, there is a methodological shortcoming in collaborative public management research. Weak empirical validation prevents the field from improving itself as applied science. There is no single or even a set of valid, reliable, recognizable measures for analyzing and comparing different collaborations and drawing conclusions on how to foster and maintain effective collaborations (Gazley, 2008; Graddy & Chen, 2009; McGuire & Silvia, 2009; Moynihan et al., 2011; O'Leary & Bingham, 2009).

Table 2.5 Comparison of collaborative governance mode with traditional management mode in post-disaster reconstruction

Category	Traditional management mode	Collaborative governance mode
Participants/ Stakeholders	Government	Multiple stakeholders, including governmental, non-governmental, and community-based actors
Structure	Hierarchical structures, rigid boundaries, and red-tape	Horizontal network with less rigidity, more flexibility, and non-hierarchical structures
Process	Command-and-control oriented process.	Consensus-oriented decision-making process
Outcome	Short-term outcome	Long-term outcome with considering process outcome, policy outcome, management outcome
Governance forms	Direct interactions within organizations	Cross-organizational interactions
Coordination mechanisms	One-way dimensional relational model. It relies on top-down hierarchical power control.	Multidimensional relational model. It is based on mutual trust, mutual understanding, internal legitimacy and shared commitment. All stakeholders will be directly included in the decision-making process.

Secondly, collaborative governance researchers are just warming up to the importance of the already emerged new forms of collaboration. Although the literature of collaborative governance is rich in insights from numerous disciplines, it suffers from blind spots concerning theoretical diversity and fragmentation and lacks depth (Nesbit & Reingold, 2011). There is a need for a new approach to understanding the complex and non-linear system. For example, the present research tends to limit itself to cross-sectional analysis with often a retrospective perception of collaborative management cases, whereas we need to understand how collaboration actually performs over time from its inception to its culmination.

The abovementioned limitations illustrate although CG is an effective framework to manage the post-disaster reconstruction, it does not make explicit the dynamic interrelationship among actors involved and related performances. Therefore, this calls for a Dynamic Performance Management approach, which can be used to assess the ability of the collaborative governance to obtain its goals from different levels are needed.

Chapter 3 Analysis of collaborative governance in post-disaster reconstruction through a Dynamic Performance Management approach

3.1 Introduction

Chapter 2 offers a detailed review of the collaborative governance in post-disaster reconstruction. The studies investigating collaborative governance are rich in insights from numerous disciplines and it has been an important approach to manage post-disaster reconstruction. This chapter aims to show how collaborative governance can help the post-disaster reconstruction phase, using the lens of the dynamic performance management framework.

In recent years, China, the Americas, the European Union and, particularly, developing countries were strongly affected by earthquakes, floods, cyclones, volcanic eruptions and other natural disasters. To understand the relevance of these phenomena, it is worth recalling what has been mentioned in Chapter 1. Only in 2018, the United Nations counted 315 natural disasters, 11,804 deaths, over 68 million people affected, and US$131.7 billion in economic losses across the world. Such events did cause not only substantial economic loss but also endangered social harmony and stability.

Public organizations are often in the dominant position to cope with all aspects of disaster management, including losses in lives and property. Although studies focusing on disaster management are not new in the area of public management, only in the 1980s and, particularly, in 1990s, they became of interest for researchers and practitioners. Though in the 1980s, the growing number of research and practice in the disaster management made a substantial advancement (Comfort et al., 2012), the major disasters occurred in the 1990s actively contributed to generate a further evolution of the emergency management literature. New scholars oriented their works to understand and explain what conditions led to damaging consequences for communities exposed to risk (Schneider, 1995). Important initiatives, such as the National Science Foundation program titled “Enabling the Next Generation of Hazards Researchers”

(Comfort et al., 2012), also raised the need to adopt a multidisciplinary approach to disaster management. Today, disaster research transcended its disciplinary borders and has become a relevant interdisciplinary field, ranging from urban planning, sociology, geography to public policy and management.

However, difficulties in managing effectively major events, such as 9/11 and Hurricane Katrina, highlighted gaps in disaster management theories and practices. Notably, the diffused disaster management approach focusing mainly on the response phase, as opposed to preparedness, mitigation, and recovery, revealed its ineffectiveness. To overcome such limitations, researchers started exploring new issues of inter-governmental and inter-organizational collaboration, communication processes and information technology in the design and management of disaster operations (Comfort et al., 2012). The analysis of the above interrelationships made evident, more than in the past, the limits of stand-alone public sector interventions. Public, profit and non-profit organizations and the public have become more aware that to solve complex and difficult social problems, such as disasters, require active collaboration among actors.

This shift of research focus on understanding the relationships between the multiple institutions, profit and non-profit organizations in building productive capacity to mitigate risks and respond to damaging events, confirmed the critical role of collaboration in strengthening society’s ability to cope with such extreme events (Boin & ‘tHart, 2010; Kapucu, 2005; McGuire, 2006; Waugh & Streib, 2006; Wise, 2006). To identify the key actors involved in these events and to examine the degree of centralization/decentralization of authority, researchers stressed the use of network analysis (Irvin & Stansbury, 2004; Imperial, 2005; Agranoff, 2006; Maguire, 2006; Head, 2007; Herranz, 2008; Comfort et al., 2012).

In spite of the efforts to offer new methods and theories of collaborative performance (Haynes & Ghosh, 2008), there is still a lack of empirical works measuring outcomes (Nohrstedt, 2013; Kelman & Rauken, 2012). Such deficiencies appear more evident, if we consider that previous studies often adopted a narrow perspective focusing on the performance of single organizations as opposed to measures of the network (Mandel & Keast, 2008). In addition, the use of a short-term perspective and a sectoral approach in the formulation and implementation of strategies therefore tend to lead to a static view of the system and to a lack of coordination between different public agencies, nonprofit and private stakeholders (Bianchi et al., 2017).

Although applying network analysis in post-disaster reconstruction can make explicit the functional and dysfunctional links inside it, it shows multiple drawbacks. It does not effectively contribute to identifying those factors explaining variations in performance across collaboration, neither specify performance measures able to explain such differences (Nohrstedt, 2013; Robinson & Gaddis, 2012; McConnell, 2011). In addition, it also neglects how the dynamic interrelation between different actors intervening in the crisis management impacts on the overall performance (Kapucu & Demiroz, 2011).

Taking into account these limits, the contribution of this chapter is to offer a framework to make explicit the interrelationships between different actors involved in post-disaster reconstruction and appropriate performance outcomes. To this intent, this study applied the Dynamic Performance Management approach (Bianchi, 2016) to the analysis of collaborative governance in post-disaster reconstruction practice. This perspective makes explicit how available strategic resources may impact on performance drivers, thereby influencing the outcomes of collaboration. Therefore, it offers a framework to support decision-makers in identifying key measures to monitor and designing effective policies to improve collaborative governance in post-disaster reconstruction activities. To best of authors' knowledge, the use of the Dynamics Performance Management represents a novel approach to frame the performance outcomes of collaborative governance in post-disaster reconstruction.

The chapter is divided into five sections. The first section briefly introduces the background and the relevance of this study. The second gives a brief review of the literature in performance management for post-disaster reconstruction and outlines the main limitations of performance measurement in this area of research. The third section is the theoretical background. First, it analyses the collaborative governance in post-disaster reconstruction, then it explains the shifting from a static evaluation of the performance management for collaborative governance in post-disaster reconstruction to a dynamic approach. In the fourth section, after introducing the Dynamic Performance Management (DPM) perspective, based on the analysis of multiple post-disaster case studies, it offers the DPM framework to investigate the performance of collaborative governance in post-disaster reconstruction. In the last section, conclusions and study limitations are provided.

3.2 Literature review of performance management in post-disaster reconstruction

Post-disaster reconstruction, while clearly critical in restoring the affected community, can also provide new opportunities for economic growth, future vulnerability reduction and sustainable development. However, in reality, the reconstruction projects are often carried out on an ad hoc and emergency basis without appropriate policies and guidelines, leading to poor outcomes, particularly after large-scale disasters (Masuriera et al., 2006). Previous studies reveal that many reconstruction projects failed to deliver on time or within budget, while failing to integrate sustainable development priorities into reconstruction processes either (Zou & Wilkinson, 2008; Wiek et al., 2010). Therefore, it is crucial to improve performance levels of reconstruction projects through appropriate procurement approaches and more structured co-ordination of the various stakeholders and contributors.

Scholars in the field of post-disaster reconstruction have long been aware of the responsibility and performance of participants, such as government organizations, market entities, and social organizations across the different phases of post-disaster reconstruction (Stallings & Quarantelli, 1985). In the early stages of post-disaster reconstruction, government agencies, particularly within the central government, have clear obligations to respond. Aguirre (1994) noted that when a disaster impacts a region, to the extent that local governments cannot cope with the problem effectively, the central government must then play a primary role in the organization, coordination, and implementation of post-disaster recovery and reconstruction. Rietjens et al. (2007) observed that compared with local governments, central governments have greater capacity and authority to mobilize resources to cope with disasters. Regarding the role of enterprises and non-profit organizations (NPOs) in post-disaster recovery, Huang et al. (2018) proposed that when a community encounters a disaster, the ability of local enterprises to survive is an important factor in the recovery process, given the socioeconomic role that enterprises play in the community by providing jobs, goods and services, and tax revenue. Kapucu (2006) found that unlike government agencies and private organizations, NPOs are better positioned to respond to the needs of local communities because of their close and ongoing relationships with the communities they serve.

Dozens of synthetic performance evaluation methods have been developed to date (Sun & Bi, 2010). These methods all have different mathematical formulae, and their data requirements and effects are also unique to each approach. However, not all of the necessary knowledge is derived from data and principles. It is impossible to utilize a single method for all possible conditions, or to emphasize a single mathematical method. Therefore, choosing the proper method is a fundamental problem (Tweed & Walker, 2011). It is necessary to analyse the characteristics, commonalities, advantages, and disadvantages of various methods to correctly understand the substantive contents of those methods, and to select an appropriate evaluation approach.

It is also necessary to analyse the type of phenomenon and its internal structural relationships to select the appropriate evaluation method. In a practical problem, the evaluated object may have many uncertainties (Gallopín, 2006). Such problems are characterised by high complexity, so it is necessary to choose a specific evaluation method in accordance with the dominant phenomenon.

In summary, the scope of a disaster area can be extensive, priorities are difficult to detect, and the relationships of various elements presented in a disconnected state. Therefore, an appropriate evaluation method taking into account the above level of complexity is needed.

3.3 Theoretical background

3.3.1 Collaborative governance analysis in post-disaster reconstruction

Reconstruction is a crucial part of disaster recovery. Successful post-disaster reconstruction is important for psychological, physical, and economically sustainable community development and significantly reduces the vulnerability to future hazards (Lawther, 2009; Li et al., 2017). When catastrophic disasters strike, besides the government, profit organizations, non-profit organizations and the public are also involved in the reconstruction. Therefore, it is vital to investigate collaborative governance to overcome the complexity and uncertainties in post-disaster reconstruction. This section will discuss the collaborative governance during post-disaster reconstruction practice in details based on ten major events of disasters since 21th century (Table 3.1).

Table 3.6 Post-disaster reconstruction analysis in publication

No.	Disaster	Time	Country	List of sources
1	Gujurat Earthquake	2001	India	(Nikhileswarananda, 2004; Fujieda et al., 2004)
2	Bam Earthquake	2003	Iran	(Ghafory-Ashtiany & Hosseini, 2007; Omidvar et al., 2010)
3	Indian Earthquake and Tsunami	2004	Indonesia and Sri Lanka	(Karunasena & Rameezdeen, 2010J. Shaw & Ahmed, 2010)
4	Hurricanes Katrina	2005	United States	(Kates et al., 2006; Colten et al., 2008)
5	Wenchuan Earthquake	2008	China	(Chang et al., 2011; Huang et al., 2018)
6	Haiti Earthquake	2010	Haidi	(Bilham, 2010; Zanotti,2010)
7	Canterbury Earthquakes	2010-2011	New Zealand	(Thornley et al., 2015; Brown et al., 2015)
8	Tohoku Earthquake and Tsunami	2011	Japan	(Fuse & Yokota, 2012; Santiago-Fandiño et al., 2017)
9	Hurricane Sandy	2012	United States	(Manuel, 2013; Olshansky & Johnson, 2014)
10	Gorkha Earthquake	2015	Nepal	(Gautam & Chaulagain, 2016; Sharma & KC, 2017)

In order to better understand how collaborative governance is achieved in post-disaster reconstruction practice, a stakeholder analysis has developed as a tool with different purposes in its application in the field of policy, management and development planning (Varvazovszky & Brugha, 2000). It aims at identifying the key factors and the stakeholders of the system on the basis of their attributes and interrelationships (Brocklesby et al., 2002). Stakeholder analysis can be used in post-disaster to assess potential support or opposition to the reconstruction process among the interested parties, such as the impacted people, government, profit and non-profit organizations (Asgary et al., 2006). A stakeholder is defined as persons, group, organizations, etc., that have a ‘stake’ in the reconstruction, whose support is needed. A stakeholder may oppose to the reconstructions plans, policies, or projects if it considered inadequate. Stakeholders' analysis identifies the key actors and analyses their relative power, influence priorities, resources, and their impact in the entire reconstruction process. Stakeholders in a post-disaster usually can be classified into four categories:

- Government (national and local), encompassing public and semi-public entities in a wide range of sectors and roles.
- Profit organizations, including the business and industrial groups. Some of them play the roles of disaster victims as well as stakeholders in the reconstruction practice.
- Non-profit organizations, such as NGOs, civic groups, voluntary associations, and professional groups.
- The public, referring to the community members and citizens' group. They are people who have been impacted by the disaster and many of them are directly involved in the reconstruction process.

Post-disaster reconstruction requires a deeper collaboration among different multi-stakeholders. The collaborative governance among these different stakeholders is critical for performance management in post-disaster reconstruction.

(1) The collaborative governance between governments

Post-disaster reconstruction is one of the major responsibilities of government at both the national and local levels. It may involve an element of competition between central, regional and local levels of government for control of the process (Rolfe & Britton, 1995). Government is not the main actor in recovery, but it is an important one. It is uniquely positioned to provide leadership, mobilize financial resources, provide technical assistance to public and private actors, and invest in infrastructure and public facilities. Government can become a credible data repository and serve as a focal point of communications. Central governments are equipped to provide guidance and control over building and settlement activities, while the local government responsible for local area development has a key role in achieving the resilience of the cities under their jurisdiction. Such a schema can be detected in several part of the world. For instance, the National Civil Defense Emergency Management Strategy (MCDEM) states that New Zealand's recovery planning and management arrangements should coordinate planning at the central level. Regional and territorial authorities are encouraged to produce group plans that will suit peculiar conditions of their local areas (Angus, 2004). Similarly, in 2004 Indian Earthquake and Tsunami, the involvement of local government in disaster resilience was very limited, as it was carried out by central government. Local governments did not possess adequate resources and they did not receive any legislative power by the country's Disaster Management Act (NBRO, 2009).

(2) The collaborative governance between government and profit organizations

Profit organizations have a critical role in humanitarian interventions and post-disaster recovery. Haigh and Sutton's research supports the use of multi-national construction enterprise resources to fill the human knowledge gap in post-disaster recovery, particularly in project management and engineering expertise (Haigh & Sutton, 2012). Yamamoto and Ashizawa (1999) suggest that private enterprises can be regarded as a valuable partner for humanitarian activities because they can bring a sense of accountability and a result-orientated attitude. Despite this, to tackle some of the challenges usually encountered following a disaster, Gunewardena & Schuller (2008) suggest that national and local governments need to embrace the private sector. The reconstruction agencies could play irreplaceable roles in providing skill advisers, training, technology, funds, and planning tools to help local authorities improving their ability to coordinate and to make decisions. In the reconstruction process of Gorkha Earthquake, capacity building of local engineers, technicians, craftsman, and contractors in aseismic construction was one of most important activity for the long-term success of the reconstruction program. Meanwhile, when disasters occur, the bulk of physical damages and economic losses are incurred by the profit organizations as well. Therefore, the support from governments is also indispensable in the recovery of these profit organizations.

(3) The collaborative governance between government and non-profit organizations

Generally, for reconstruction projects, governments, and NGOs have been found to have common goals and visions with respect to social sector development, particularly in health and nutrition, poverty alleviation, human resource development, environmental protection, non-formal education, and the development of women (Ahmad, 2001). Further, a good relationship between governments and NGOs can improve the efficiency and quality of post-earthquake reconstruction. One one hand, it has been observed that NGOs can provide differentiated public services and can complement government work. This is due to the fact that NGOs and the government have similar post-disaster reconstruction objectives. NGOs can identify and provide differentiated community services in areas that the government does not have the capacity to deliver goods and services (Derthick, 2007). On the other hands, NGOs can reallocate or coordinate non-government resources and supervise effective resource utilization using targeted and flexible approaches, especially in volunteer recruitment and management. During reconstruction, NGOs are vital for the mobilization of volunteers and volunteer services (Eikenberry et al., 2007; Simo & Bies, 2007). For example, UNESCO has been involved in the reconstruction process of Bam Earthquake by providing scientific and technical advice, training and education, mobilizing financial assistance, and also by creating a task force to coordinate UNESCO's actions in response to the damage to one of the world heritage sites (Alavi, 2005).

(4) The collaborative governance between government and the public

The concept of community-based approach in disaster management is widely accepted and promoted around the world (Schilderman, 2004; Paxton et al., 2010). 'Community-based' means people's participation should be mobilized and sustained throughout the disaster management cycle starting from the very beginning of planning and not ending until the achievement of desired goals and institutionalization in the community. It is very common to underestimate the importance and the value of local communities' participation in reconstruction. Local people are familiar with their culture, history, customs in general and building materials, architectural styles in construction. These valuable knowledge and experience pools could provide critical references in planning, design and reconstruction of affected public infrastructure. By actively involving local communities in planning and decision-making processes, the reconstruction projects would be more likely to meet end-users needs. In the reconstruction of Bam Earthquake, Bam Reconstruction Society, as one of the civil society groups, has been very critical about the reconstruction process and often publicly demanded more government inputs, attention, investments, and accountability. In the case of Gujurat Earthquake, the government and the public strongly collaborated in overcoming land use conflicts issues, to support recovery and reconstruction phases

(Lundin, 2011). The public could also provide support to the government. In the case of the Hurricane Katrina, a bill sponsored by the U.S. Representative Richard H. Baker (from the Baton Rouge suburban in Louisiana) drew the attention of the Republican and Democratic congressional members to create a fund to buy out home and business owners in the worst damaged areas of New Orleans (Waugh & Smith, 2006).

(5) The collaborative governance between profit organizations and non-profit organizations

During post disaster reconstruction, particularly, large funds, private contractors and international NGOs very often work closely to fund and implement proposed reconstruction projects. This raises the need of coordinating the relationships between them and other community-level actors. In fact, it may happen that to maximize the chances to securing funds, beneficiary organizations tend to operate as generalists, rather than specialist. Operating as generalist may allow them to take funds from a variety of different donor types. This is the case of the organizational network structure associated with the reconstruction processes in Haiti. The perceived instability faced by different organizations involved in the reconstruction process, raised the reliance of funders on local NGOs and smaller civil society groups. In the case of the Canterbury Earthquake, with funding from the Christchurch Earthquake Appeal and ASB Bank, Leighs Construction took only 8 weeks to build a shipping container mall, which is expected to stay intact for a least a year until other downtown shopping can be restored. The reconstruction of Hurricane Sandy provides another example to illustrate the collaboration between profit and non-profit organizations. As of December 2012, about 90 organizations (such as American Red Cross and the Salvation Army) raised more than $400 million for Hurricane Sandy relief from private corporations (Chandra et al., 2016).

(6) The collaborative governance between profit organizations and the public

The most effective type of recovery organization is one that coordinates and supports existing agencies in doing what they do best. The recovery organization adds value not in performing a radical new function, but by helping existing public and private organizations to perform more effectively during the expected period of time. Profit organizations can contribute to post-disaster reconstruction in a variety of ways. Profit organizations, particularly industries, often provide their contributions to disaster recovery primarily either through single funds or through philanthropic partners. For example, in the reconstruction process of 2004 Indian Earthquake and Tsunami, private companies and donor agencies did not only provide technical experts and senior managers to carry out projects alongside local community leaders, but also generously donated equipment and other needed materials. Similarly, private organizations, such as, insurance companies, also have a direct role providing insurance claims for losses recorded during the disaster. In the post-disaster reconstruction after 2011 Tohoku Earthquake and Tsunami, quick payment of insurance claims allowed individuals and businesses to contribute fully to the rehabilitation effort (Fuse & Yokota, 2012).

(7) The collaborative governance between non-profit organizations and the public

In recent years, NGO involvement in post-disaster reconstruction has increased (Von Meding et al., 2009). They participate in the long-term reconstruction and recovery through donations and providing professional assistance, such as, for instance, psychological consultations and medical services. With their professional background and rich experience in disaster management, NGOs have great potential in social reconstruction. Though many NGOs are specialized in different areas of relief, their scares resources very often imply to build up multiple collaborations with other stakeholders. Such experiences, however, can contribute to raise NGOs problem solving competences, which in turn may result in lower stakeholders' conflict probability (Lukaszczyk & Williamson, 2010). To achieve shared goals in the delivery of relief aids, inter-organizational collaboration among NGOs uses cooperative decision making and resource sharing, which improves both the use of organizational resources and service delivery effectiveness (Meier & O'Toole, 2001). This, in turn, is likely to corroborate NGOs capabilities to cope with complex post-disaster challenges (Gray & Wood, 1991). In contrast, a lack of cooperation can result in a significant waste of resources both in relief delivering and administrative costs. From the extensive field research and case studies analysis conducted in the post-Wenchuan earthquake-stricken communities, Lu and Xu (2015) detected different types of NGOs working with communities, through multiple collaboration efforts. The International NGOs (INGOs) usually collaborated with communities by supporting infrastructure system reconstruction, protecting the eco-environment. The government related NGOs

(GONGOs) contributed in housing and public service facilities rebuilding and disaster prevention. For instance, one of the GONGOs began its relief operations immediately after the 2008 Wenchuan earthquake, and by 30 June 2009 it donated a total of USD 28 million to the affected areas (Lu & Xu, 2015). Finally, the Civil NGOs (CNGOs) participated in the area of mental health and specialized care for targeted populations.

The task of reconstruction, as indicated by United Nations (2008), demands a high level of coordination and a careful managerial approach. According to the above analysis, we can assert that the governance model of the post-disaster reconstruction of a natural disaster is a lead organization form (Kenis & Provan, 2009). Lead organization governance is common in a network where there are a single powerful actor and many weaker participants. Based on the above analysis, it appears clearly that the Government plays a leading role in the post-disaster reconstruction. The non-profit organizations, the private sector and the public, work under the formal guidance of the Government (see full line in Figure 3.1). To carry out the single responsibilities assigned in the post-disaster management, network members can also interact with each other informally and spontaneously (see dotted links in Figure 3.1). Therefore, it can be concluded that the single performance of multiple stakeholders involved in post-disaster reconstruction should be reconsidered through the collaborative governance framework.

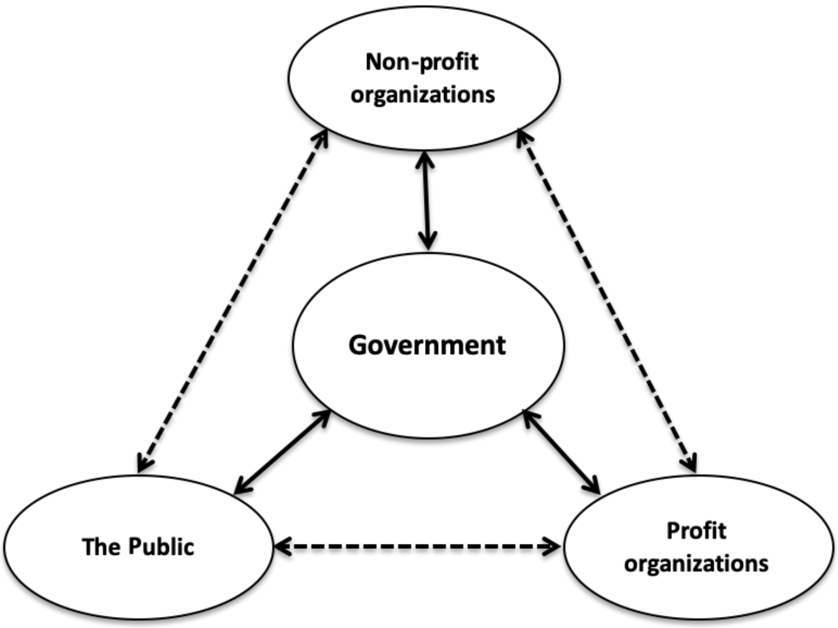


Figure 3.1 Collaborative governance framework in post-disaster reconstruction

The central role of the Government in such a framework also points out that government credibility, and leadership, are critical factors in successful collaborative governance.

The above remarks raise the need to support public decision-makers to design a comprehensive framework to evaluate the relationships between network members during the phases of post-disaster reconstruction. Such a framework should, therefore, focus not on the single organization's performance, but instead on the collaborative outcomes. The next section discusses the use of the DPM perspective to investigate the interrelationships between different actors involved in post-disaster reconstruction and to design appropriate performance outcomes.

3.3.2 The relationship between collaborative governance and performance management in post-disaster reconstruction

Performance management is still an important and challenging issue in post-disaster reconstruction, especially when the problem is discussed from a collaborative governance perspective (Kapucu & Demiroz, 2011; Nolte & Boenigk, 2012). Collaborative capacity building is a difficult task for public managers, which requires fostering relationships and forming creative teams and networks (Senge et al., 2008). It requires the design and use of more ambitious and multifaceted performance management systems that can trigger decision-makers' learning and coordination, strength their aptitude in framing dynamic complexity, and support them in pursuing sustainable outcomes.

It is not surprising that there is little research on the relationship between performance management and collaborative governance (Emerson & Nabatchi, 2015). Despite the attention to performance management in government, there is relatively little empirical research on the explicit interconnection between management approaches and outcomes in public management literature (O'toole et al., 2005). It is even more problematic to link management processes with collaborative outcomes. The network-specific challenges of identifying and measuring collaborative performance include: multiple, sometimes vague, objectives or goals that most networks seek to achieve; the use of multiple, simultaneous management or coordination strategies; multiple, simultaneous structure and process dynamics at work in networks, which are influenced by, but distinct from, coordination strategies; and the influence of exogenous forces on network performance (Heranz, 2010). Because of these difficulties in assessing collaborative governance, a few studies even suggest that there is a relation between the structure of collaborative networks and outcomes related to management processes, program services, and effects on clients (Selden et al., 2006).

Building on categorizations of the main public governance principles and processes by Kooiman (1993), Rhodes (1997) and Bovaird and Loffler (2003), there is clearly a need to assess such principles of "good governance" as citizen engagement, transparency, accountability, human rights, the equalities agenda and social inclusion (gender, ethnicity, age, religion, etc.), ethical and honest behavior, equity (fair procedures and due process), respect for the rule of law, fair conduct of elections, representation and participation, and sustainability. These principles and processes of public governance are not absolute. Their importance is likely to vary between contexts and over time, and different stakeholders are likely to have different views on what they mean and how important they are. This suggests a "governance impossibility theorem", as it is very unlikely that all of these principles can simultaneously be implemented to desired minimum levels. The assessment of the achievement of public governance principles has mainly been undertaken on a piecemeal, principle-by-principle basis, with different methodologies developed to assess transparency and corruption (e.g., by Transparency International), accountability (e.g., by public audit offices), partnership working, etc. (Bovaird & Loffler, 2003, 2007).

Network perspectives is a one of the tools used to measure the performance of collaborative governance. The use of network analysis techniques can improve the effectiveness of a network (intra-organizational or interorganizational) by identifying points of misalignment and accelerating collaboration in the right places. This can determine whether certain organizations and functions achieved the required connectivity for pursuing the desired results. It also identifies and monitors intervention strategies if the demanded level of interrelationships among actors is not reached. Network analysis can also identify high performers in a network and determine success reasons and replication factors for low-performing actors (Provan et al., 2005). In addition, network performance analysis provides an empirical and visual map of the interactions among members, the structure of the network and the characteristics of network participants. Moreover, network analysis supplies a broad perspective of network processes, outlining linkages and structural properties of social relationships (Mandell & Keast, 2007).

Many studies recognized the importance of collaboration in post-disaster reconstruction and analyzed the practical results (Bodin & Nohrstedt, 2016). These scholars focus on the quality of public services, the quality-of-life outcomes, and the achievement of public governance outcomes. All of them claim a high level of political importance for this area of research. Separate evaluation of the performance of each dimension in collaborative post-disaster reconstruction is unsatisfactory, for at least two reasons. First, it loses its system nature of the network, and adopts a static rather than a dynamic dimension. In the long-time horizon and dynamic processes of post-disaster reconstruction, how do the relationships between main actors responsible for reconstruction impact on collaborative governance performance outcomes? To properly answer this research question, this chapter illustrates how the DPM modelling perspective can be used to support policy makers in addressing this wicked problem. Such modeling applies the system dynamics methodology (Forrester, 1961; Sterman, 2000) to investigate how a given phenomenon perform over time. Within a supportive learning environment with experienced facilitators, policy makers can use these insights to enhance their understanding of the causes and effects relationships, and to identify sound policies to govern wicked issues (Bianchi et al., 2017).

3.4 Applying Dynamic Performance Management to analyze the collaborative governance in post-disaster reconstruction

3.4.1 The Dynamic Performance Management perspective

The Dynamic Performance Management (DPM) perspective (Bianchi, 2016) combines traditional Performance Management (PM) systems and System Dynamics (SD) modelling. It aims to support the strategic learning processes of public sector decision-makers with the intent to manage organizational performance (Bianchi, 2012, 2016; Bianchi & Tomaselli, 2015). It can be defined as a modelling approach to design and implement more reliable PM systems in public organizations.

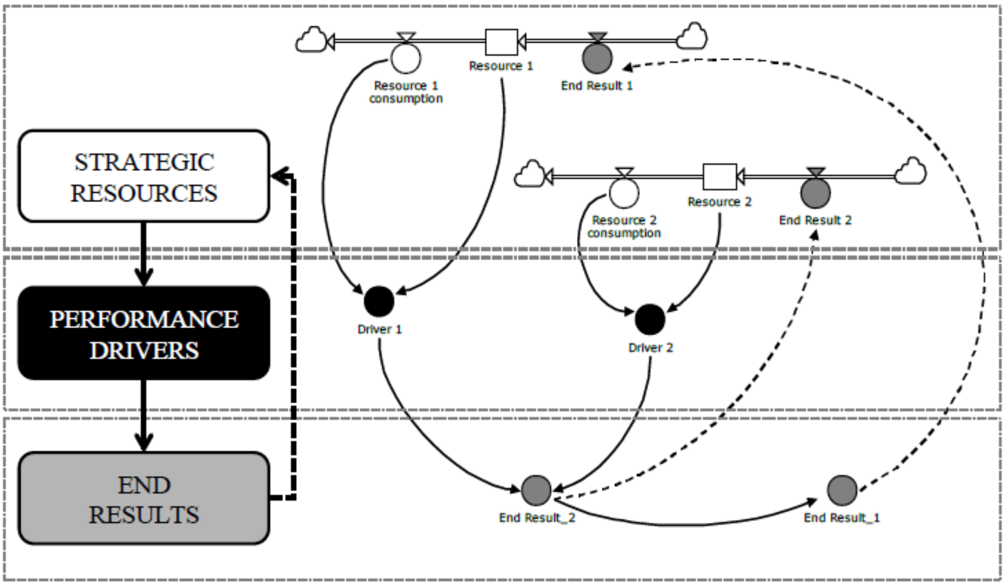


Figure 3.2 The Dynamic Performance Management view
(Bianchi, 2016)

Table 3.2 Summarizes the symbols and related meaning in a typical system dynamics model
(Sterman, 2000)

Stock	An element of a system that accumulates or drains over time. Stocks are the memory of a system and are only affected by flows.
Flow	The movement of people or things between stocks within a system boundary or across the model boundary and thereby into or out of the system (through sinks and sources); changes in stocks over time.
Converter	A variable that is not a flow and is capable of changing its value instantaneously.
Causal link	A relationship between two variables with the direction of causality and the direction of impact.

Figure 3.2 depicts the “instrumental” dimensional of the DPM perspective. Such a framework illustrates how strategic resources allocation may affect performance drivers and end-results. It also highlights how end-results, in turn, are likely to influence strategic resources. While these changes on the strategic resources generated by the end-results are indeed important, they only provide one, limited snapshot. To

understand the long-term results of the overall system, it is important also to focus on the performance drivers, i.e. the critical success factors for achieving these end-results. To influence the achievement of the desired outcomes, performance drivers should be measured and monitored, and, where possible, changed to a more favourable state. Performance drivers are measured as ratios between the current strategic resource levels affecting performance and the desired levels (Bianchi et al., 2017). For example, the performance of resource allocation capacity, as an essential factor to evaluate post-disaster reconstruction ability, can be assessed by the ratio of perceived resource allocation capacity and desired response time ratio. It is crucial also to outline the policy options which are believed to affect the strategic resources. Through the action on such policies, decision-makers can influence performance drivers, and – through them – end-results, which in turn will feedback on the strategic resources. Explanation of the symbols used in Figure 3.2. is given in Table 3.2.

This study aims to investigate the interrelationships of different actors involved in post-disaster reconstruction. Particularly, understanding how strategic resources affect performance drivers and end-results, it becomes a key-issue to manage the performance in such a dynamic and complex public sector (Oh & Bush, 2015). Such an approach allows us to make explicit performance outcomes both in the short and in the long run. Furthermore, it does not only focus on the perspective of a single organization but the relevant system.

Since time disjunctions between actions and results, and non-linear feedback relationships affecting policy outcomes, a DPM approach is particularly valuable in such contexts. It implies that decision-makers cannot easily understand the structure and behavior of the systems in which their policies will be implemented (Bianchi, 2016). Therefore, the use of system dynamics quantitative models is particularly encouraged (Sterman, 2000). At present, this study focuses only on the qualitative side of the analysis, e.g., it aims to capture and to make explicit the causal relationships inside the DPM in post disaster reconstruction. At a later stage of this analysis, a quantitative simulation model will be built in the next chapter. Through such a dynamic model changes over time in outcome measures, performance drivers and strategic resources will be outlined and investigated to influence the management performance of post-disaster reconstruction.

3.4.2 The design of a DPM framework to investigate the performance in post-disaster reconstruction

The DPM framework is built using the "instrumental" view, which is the first step to designing and implementing a full DPM system. The next step would imply the building of a simulation model capturing the quantitative and dynamic interrelationships among the variables included in the DPM framework. The simulation model will be built in the next chapter.

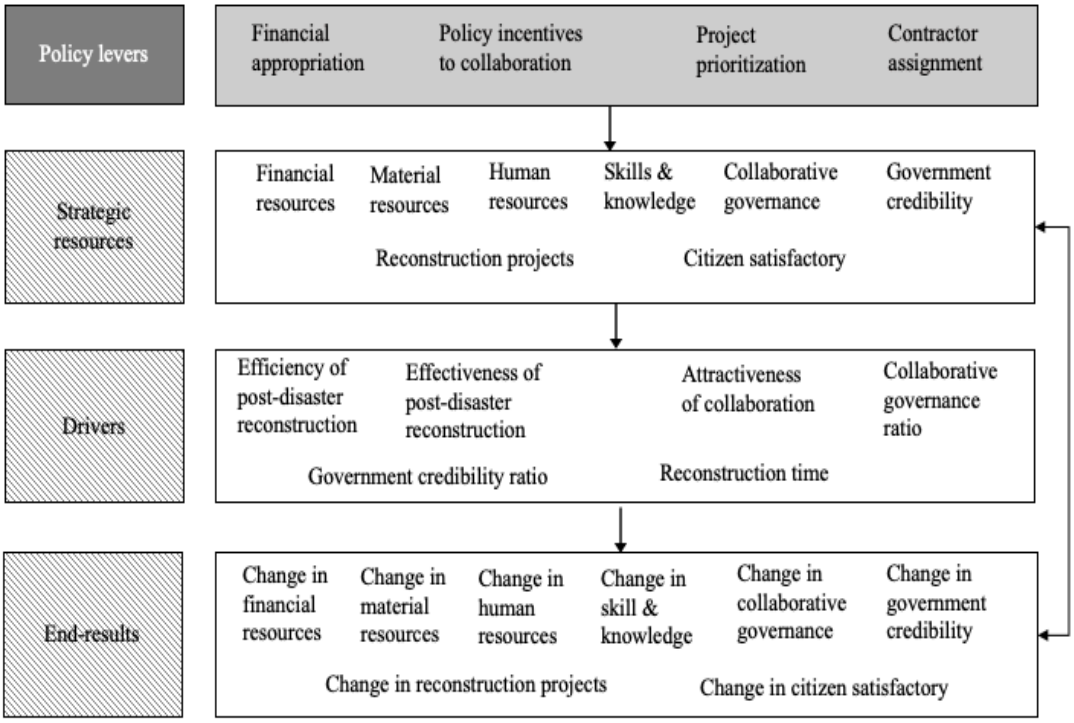


Figure 3.3 A simplified DPM framework to evaluate collaborative governance in post-disaster reconstruction

Figure 3.3 sketches a generic dynamic performance management model related to post-disaster reconstruction. It describes an example of dynamic performance management framework focusing on the role of six performance drivers, i.e. collaborative governance ratio, efficiency of post-disaster reconstruction, effectiveness of post-disaster reconstruction, reconstruction time, government credibility ratio and attractiveness of collaboration. In particular, such a framework illustrates a set of measures in relation to both performance drivers and end results regarding eight outcomes of post-disaster reconstruction practice: “change in financial resource”, “change in material resource”, “change in human resource”, “change in skill & knowledge”, “change in collaborative governance”, “change in government credibility”, “change in reconstruction projects”, and “change in citizen satisfactory”.

End-results are influenced by corresponding performance drivers. Taking the end-result “change in citizen satisfaction” as an example, it is influenced by the reconstruction time, efficiency of post-disaster reconstruction and effectiveness of post-disaster reconstruction. The reconstruction time represents the time required to recover to the original state after the disaster. It has a negative effect on citizen satisfaction. Efficiency of post-disaster reconstruction indicates to what extent that resources, efforts and time is wasted in the reconstruction practice. While effectiveness of post-disaster reconstruction states to what extent the disaster damage is recovered. Therefore, efficiency of post-disaster reconstruction and effectiveness of post-disaster reconstruction on have a positive effect on citizen satisfaction. Consequently, a long reconstruction time generates an adverse change in citizen satisfaction. This phenomenon is likely to lead to citizen satisfaction strategic resource decline. A low level of citizen satisfaction deteriorates performance drivers, such as government credibility ratio, which in turn generates a reduction in collaborative governance. The decrease of collaborative governance will impress the reconstruction progress, which in turn leads to a high reconstruction time. This leads to a vicious cycle (Loop R1 in Figure 3.4). Beyond that, the change in government credibility is determined by the reconstruction time, efficiency of post-disaster reconstruction, effectiveness of post-disaster reconstruction and collaborative governance capacity. An increase in government credibility ratio impacts on the change in collaborative governance. This may generate a reinforcing loop leading to a positive change in strategic resources (Loop R2 in Figure 3.4). The same reasoning can be applied to explain the changes in resource supply and collaborative governance. More detailed cause-effect feedback loops will be introduced in the next chapter.

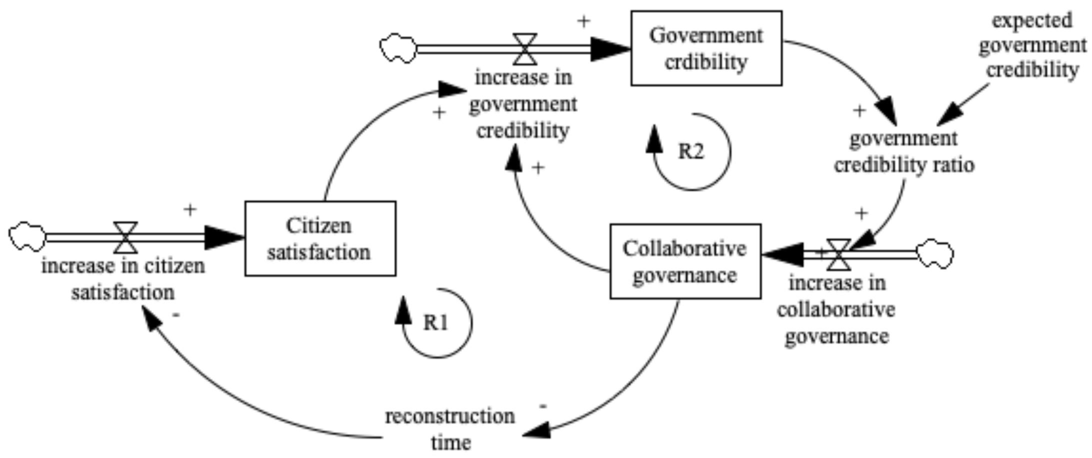


Figure 3.4 An example to illustrate accumulation and depletion process affecting collaborative governance strategic resource, performance drivers and end-results

Notes: The arrows indicate causal relationships directed towards the arrowheads; a plus sign (+) denotes a positive polarity, indicating that the effect variable develops in the same direction as the cause variable. Similarly, a minus symbol (−) denotes a negative polarity, indicating that the effect variable changes in the reverse direction of the cause variable. R signifies this is a reinforcing loop.

This framework aims to help public decision-makers to identify the endowment of strategic resources required to manage the collaborative governance in post-disaster properly. The acquired assets can then positively influence performance drivers, which may, in turn, generate a more significant impact on performance outcomes. It depicts a qualitative and generic or "insight" DPM model, rather than a detailed, customized, and quantitative DPM model, it can add value to policy design, since it can support communication and coordination among policy makers. In particular, identifying the variables related to the three different dimensions of performance, and framing the hypothesized causal pathways leading over time to changes in the performance drivers and the end results, is critically important. It allows the identification of design flaws in the system and interactive feedback effects which have been ignored or misunderstood. On the back of this "insight" model, a more detailed and calibrated model can be developed to support more detailed assessment of specific policies and a quantitative comparison between alternative decision sets.

The model in Figure 3.3 is at quite a high level of generality in relation to coproduction processes. When coproduction is analysed in more detail, separate approaches can be distinguished which involve relevant citizens in co-commissioning, codesign, co-delivery, and co-assessment (Bovaird et al., 2017). Each of these four Cos entail a different process by which citizen involvement can make public services more cost-effective and more closely aligned to the outcomes which citizens want. In this case, there may be some automatic gains in terms of achievement of governance principles—e.g., transparency is likely to be easier to achieve, since citizens are more closely involved in decisions and in actions. Moreover, citizens may be prepared to trade-off some other governance principles, as they are closely involved in decisions—e.g., there may be less need for formal accountability or citizen engagement mechanisms.

3.5 Conclusions

This chapter explores the different complexity factors underlining collaborative governance in post-disaster reconstruction. Very often performance systems are designed to capture results provided by the single actor inside the network, rather than approaching it through a holistic perspective. In fact, it has been shown that the use of a DPM approach is particularly effective in: a) highlighting the interaction between stakeholders involved in the collaborative governance and b) to support decision-makers to design a set of outcomes able to deal with such a dynamic complexity.

Therefore, this study confirms the importance of key performance drivers and end-results in the collaborative network of post-disaster reconstruction. The DMP framework provided in this preliminary study aims to support decision-makers to gain an in-depth understanding, in terms of complexity and system interdependencies, of the network cooperation in post-disaster reconstruction. Neglecting such a level of interactions among stakeholders engaged in the network may lead to the design of ineffective and short-term policies.

In the next chapter, based on the qualitative DPM framework, a quantitative system dynamics model will be built and simulated to help managers make effective strategic decisions to enhance the collaborative governance in post-disaster reconstruction.

Chapter 4 System dynamic model to support collaborative governance in post-disaster reconstruction

4.1 Introduction

Disasters—such as floods, hurricanes, and earthquakes— cause loss of life and property. Effective post-disaster reconstruction should be conducted to build community resilience to address physical, social, environmental, and economic vulnerabilities and reduce vulnerability to future disasters. Considerable interest has been generated in the study of post-disaster reconstruction in the past decades. Some works done in this field of research are: Thanurjan & Seneviratne, 2009; Liu et al., 2016; Peng et al., 2013; He, 2019; Aliakbarlou et al.,2017; Ho, 2005.

Disasters generate devastating damage to economic and social aspects. In particular, they generate unusually large and immediate losses of the overall built environment, including residential, commercial, and industrial facilities in addition to civil infrastructure (Olshansky et al., 2012). Many researchers on disaster management have paid attention on reconstruction process at both regional- and project- level with a focus on a resource supply chain management (Le Masurier et al., 2006; Orabi et al., 2010), debris disposal management (Swan, 2000; Shen et al., 2004) and preparing and planning to the impact of disasters on civil infrastructure (Chen & Tzeng, 1999; El-Anwar et al., 2009; Orabi et al., 2009). This is because the reconstruction of damaged civil infrastructure systems needs to be carefully planned in order to alleviate the impact of disasters on local communities (Karlaftis et al., 2007).

These researches, unfortunately, show a lack of analysis on collaborative governance in post-disaster reconstruction. More importantly, there are a few works done on these topics using a system dynamics approach. Ramezankhani and Najafiyazdi (2006) proposed a system dynamics model in order to simulate the activities in the zone after the earthquake has shaken the city. Hwang et al. (2014) conducted a case study to analyze the effectiveness of governmental plans and provided policy implications, which focuses both on restoration work progress and the functional recovery of populations' social activities. Sutley and Hamideh (2018) presented a system dynamics model taking an interdisciplinary approach by applying causal factors examined by social scientists in an engineering model, to deep understanding post-disaster housing recovery. However, they did not provide a simulation model because of the difficulty to collect an appropriate data resource.

Reconstruction practice after a disaster is a series of activities, including infrastructural, psychological, demographic, economic, cultural and political reconstruction. Due to the complexity of reconstruction operations and interdependency among facilities and other elements, traditional approaches are limited in their ability to analyze multiple interdependent processes operating simultaneously. In this regard, computer simulation techniques can articulate the complex behavior of interest over time. Simulation approaches can partially overcome the empirical problem of data availability, especially in emergent post-event situation, because they focus on key-variables behaviors over time and feedback processes leading to the outcomes (Harrison et al., 2007), rather than single values/points in time.

Therefore, this chapter suggests using the system dynamics (SD) methodology (Forrester 1961; Sterman 2000) to analyze the dynamic features of a collaborative governance approach in post-disaster reconstruction. SD offers a holistic perspective by capturing main feedback processes underlining the changes in the variables of interests (Williams, 2002). This chapter focuses both on reconstruction work progress and the collaborative governance among different participants. Three fundamental questions are tackled in this part:

1) How can a system dynamic modelling help understand the dynamic of collaborative governance in the post-disaster reconstruction?
2) What are the main feedback loops affecting collaborative governance in the post-disaster reconstruction?
3) How to intervene in this feedback structure to improve post-disaster reconstruction performance (efficiency and effectiveness)?

The chapter is structured as follows. Due to the importance of collaborative governance and post-disaster reconstruction, section 1 provides a brief literature review in such field. This analysis also illustrates the reason why the SD methodology can contribute to the current research. Section 2 describes the research methodology.

Section 3 offers the theoretical background. Section 4 includes the feedback loops analysis, a DPM framework, a detailed description of the SD stock and flow model structure and the simulation results of five alternative scenarios. Section 5 discusses the main findings and provides some conclusions of this study.

4.2 Method

The chapter aims to understand the dynamic of collaborative governance mechanisms impacting on the performance of post-disaster reconstruction phase using a SD-based approach. The use of the SD model may enable decision makers to test alternative policies in a safe environment, before resources are committed. Through the use of the SD model, decision makers can experiment multiple scenarios and validate their mental models' assumptions (Sterman, 2000; Bivona et al., 2019). The SD methodology (Forrester, 1961) has been widely recognized as an effective approach to scrutinize the post-disaster reconstruction and to explore alternative scenarios and policies. Previous SD studies cover the analysis of post-disaster reconstruction processes, such as post-disaster management (Ramezankhani & Najafiyazdi, 2008), the reconstruction of urban water systems (Bagheri et al., 2010) and environmental recovery efforts (Hwang et al., 2014).

To accomplish the research object, the combination of Dynamic Performance Management (DPM) and SD modelling is suggested.

First, the DPM framework was used to identify the key elements of collaborative governance in the post-disaster reconstruction. By making explicit the causal pathways leading to changes in post-disaster performance drivers and end results, such a framework appears particular effective to support policy coordination among decision-makers. It allows the identification of interactive feedback loops which could be ignored or misunderstood in the recent past. Such a preliminary analysis can offer the basis to build a detailed and calibrated model to conduct an assessment of alternative scenarios and policies and to compare post-disaster reconstruction performances.

Second, a SD simulation model provides an analytical solution for complex, nonlinear, and dynamic systems by focusing on main interacting mechanisms among key-variables over time (Sterman, 2000; Williams, 2002; Harrison et al., 2007). SD is based on the analysis of the cause-and-effect structure of the investigated phenomenon and on the stock-and-flow diagram, which can be used to generate the investigated behavior over time. SD models also include the policies which can be activated by decision makers to change the performance of the observed system (Abdel-Hamid, 1993). SD modelling has proved to be very effective at both micro and micro level. It can be effectively used to analyze the impact of high-level decisions (e.g., reconstruction plans) or at lower level (e.g., reconstruction and functional recovery process). This analytical capability can provide decision makers a differentiated understanding of policy effects on the overall reconstruction system. Particularly, when few specific data are available, qualitative modeling can help decision-makers to conceptualize the system dynamic complexity. Where simulation models can be developed effectively, they can add to the preliminary policy design analysis, the test and measurement of alternative policies to improve system performance.

4.3 Theoretical background

Post-disaster reconstruction is a complex problem. It must be addressed as an entire system rather than in a piecemeal way. Small inputs may result in disproportionate effects; the challenges they present cannot be solved once and forever, but require to be systematically managed and typically any intervention merges into new problems as a result of the interventions dealing with them; and the relevant systems cannot be controlled – the best one can do is to influence them (Poli, 2013). Complex problems occur within a system, which is made up of interconnected, interdependent elements that work together in a nonlinear manner and produce feedback loops (Anderson, 1999; Van Beurden et al., 2011). Long-term post-disaster reconstruction is a complex system where the nature and extent of the problem differ for each disaster as a whole and for each stakeholder affected by it.

As disasters become more complex and their scale increases, post-disaster reconstruction carried out by a single organization becomes increasingly ineffective because of limited material and human resources. In addition, as the uncertainty and predictability of disasters increase, reconstruction at a single organizational level in terms of resilience causes excessive input of time and resources. Collaborative governance among governments, profit and non-profit organizations and the public is, therefore, becoming more important. At the same time, performance management of collaborative governance is also getting more and more attention. In recent research, scholars have focused on how the implementation of collaboration is achieved and how these achievements affect the collaboration among multiple actors. For example, Li and Tan (2018) found that government trust is an important factor to reduce the cost of recovery policy implementation and improve the efficiency of reconstruction after natural hazards.

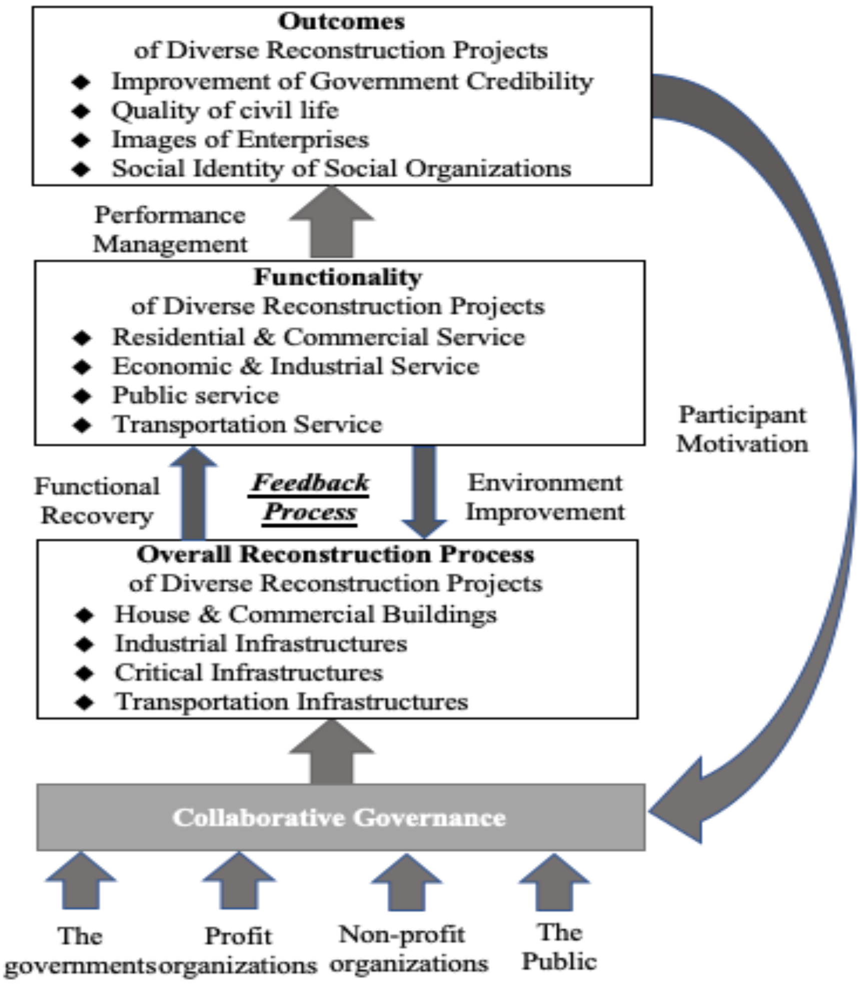


Figure 4.1 Collaborative governance in the post-disaster reconstruction (adapted from Hwang et al., 2014)

Post-disaster reconstruction systems involve repairing and rebuilding houses, commercial buildings, pathways, and critical infrastructure, such that populations are provided with products and residential, commercial, transportation, and public services (Olshansky et al., 2012). Owing to the complexity of the overall reconstruction system caused by dynamic and multiple feedback processes, as shown in Figure 4.1, effective reconstruction practice is essential to recover both the inconvenient and impoverished daily lives of populations and the interrupted operations of infrastructure to their pre-disaster conditions. Thus, there have been many research efforts to analyze and improve the reconstruction process. These efforts include resource supply chain management (Orabi et al., 2010; Freeman et al., 2014), reconstruction management (Liu et al., 2013; Mahmoud et al., 2019), business recovery (Huang, 2018), community reconstruction (Lu & Xu, 2015) and collaboration (Raju & Becker, 2013).

To overcome the limitations of a fragmented approach in the post-disaster reconstruction phase (Shoji & Toyota, 2009; Holguin-Veras et al., 2012), a collaboration among multi-stakeholders can be particularly helpful to cope with the increasing uncertainty and complexity. However, there are multiple difficulties which may prevent the success of a collaborative approach.

For instance, the lack of understanding (at the macro level) of the complexity generated by the collaboration among multiple stakeholders (in terms of, activities coordination, priorities setting, etc.), it requires a deep knowledge to manage the dynamic changes in stakeholders' relationships during the post-disaster reconstruction phase.

Computer simulation techniques can articulate the complex behavior of interest over time by testing hypotheses and formalizing new theories (Harrison et al., 2007). Particularly, SD simulation modelling can effectively address these issues owing to its powerful ability to manage multiple interdependent feedback processes operating simultaneously over time.

4.4 The SD model of the collaborative governance in post-disaster reconstruction

With the intent to investigate collaborative governance in the post-disaster reconstruction, this research attempts to draw causal loop diagrams based on the existing studies and the actual cases. For the purpose of analyzing dynamic features of reconstruction practice and its outcomes, the primary focus is to understand: (1)

collaborative governance among multi-stakeholders in reconstruction efforts; (2) feedback processes between reconstruction operations and functionality recovery; (3) the impact of collaborative governance in post-disaster reconstruction performance outcomes and (4) the feedback effect of post-disaster reconstruction outcomes on the collaborative governance among multi-stakeholders. To build a SD model, the literature points out the interactive nature of the modelling process (Richardson & Pugh, 1981; Roberts et al., 1983; Sterman, 2000).

4.4.1 Model development

(1) Problem definition

Collaboration between different participants is needed for achieving better post-disaster reconstruction performance. In this research, the role of collaborative governance in post-disaster reconstruction is analyzed from three aspects:

The availability of resources

In the aftermath of disasters, the resources available to perform reconstruction for facilities are limited because other residential, commercial facilities and core infrastructures in the disaster region also require rapid recovery of their functionality. Not only repair of facilities but also rescue efforts and disposal operation of debris from damaged structures requires materials, personnel, equipment, or any other public services (e.g., electric power, gas, water, communication networks, transportation capability, and administrative functions) as well. This causes excessive needs for resources or other services in a disaster region. In particular, the functionality loss of core infrastructure from damage can reduce pubic services supply, in turn, exacerbate the availability required services for reconstruction work. In this situation, Collaboration between public sector organizations and various actors, such as citizens, non-governmental organizations, civic groups, and businesses, is also necessary. Collaborative governance can better achieve the obtain and sharing of diverse resource and information.

The allocation of available resource

A long-term restoration process is needed to normalize the post-disaster social and natural system. The physical and human resources required for the lengthy restoration process are typically beyond the capacity possessed by a single government organization. Thus, a collaborative relationship between organizations may reduce the time and cost necessary to mobilize physical, economic, and human resources outside of the organization. In other words, duplication and redundant investments by departments are minimized, which allows the functions, resources, and information of each organization to be used more efficiently. And post-disaster reconstruction requires a mix of tasks in a very diverse area over a long period. Thus, integrating actors with different technologies and capabilities through collaboration is advantageous in post-disaster reconstruction.

The long-term outcomes of collaborative governance in post-disaster reconstruction

Long-term outcomes and collaborative governance are particularly worthy when examining the recovery process from disasters. In the long and dynamic processes of recovery, how do the primary participants responsible for recovery adapt and change to meet social and economic objectives could contribute to the formation of collaborative networks in the future. Scholars in the field of post-disaster recovery have long been aware of the responsibility and performance of participants, such as government organizations, market entities, and social organizations across the different phases of post-disaster recovery (Stallings & Quarantelli, 1985). Studies show that the trust, friendship and mutually beneficial relationships developed over the reconstruction phase can provide a strong foundation for the formation of collaborative networks, which were essential to facilitating longer term development (Tang, 2019).

(2) Concept model definition

As shown in Figure 4.2 and Table 4.1, a disaster event generates considerable need for reconstruction of the system. Facilities and infrastructures within the region can be categorized into four types or subdimensions (Shoji & Toyota, 2009). Such “Type” dimensions can be represented through array variables and distinguished in: (1) General facilities, such as residential and commercial buildings (“G”); (2) Critical facilities/infrastructures (e.g., administration offices, police stations, schools, hospitals and power communication infrastructures) that provide core public services (“C”); (3) Industrial facilities that provide industrial services and produce construction equipment and materials ("I"), such as the industry, agriculture and tourism infrastructures; and (4) Transportation infrastructure, such as roadways, railroads, and bridges ("T").

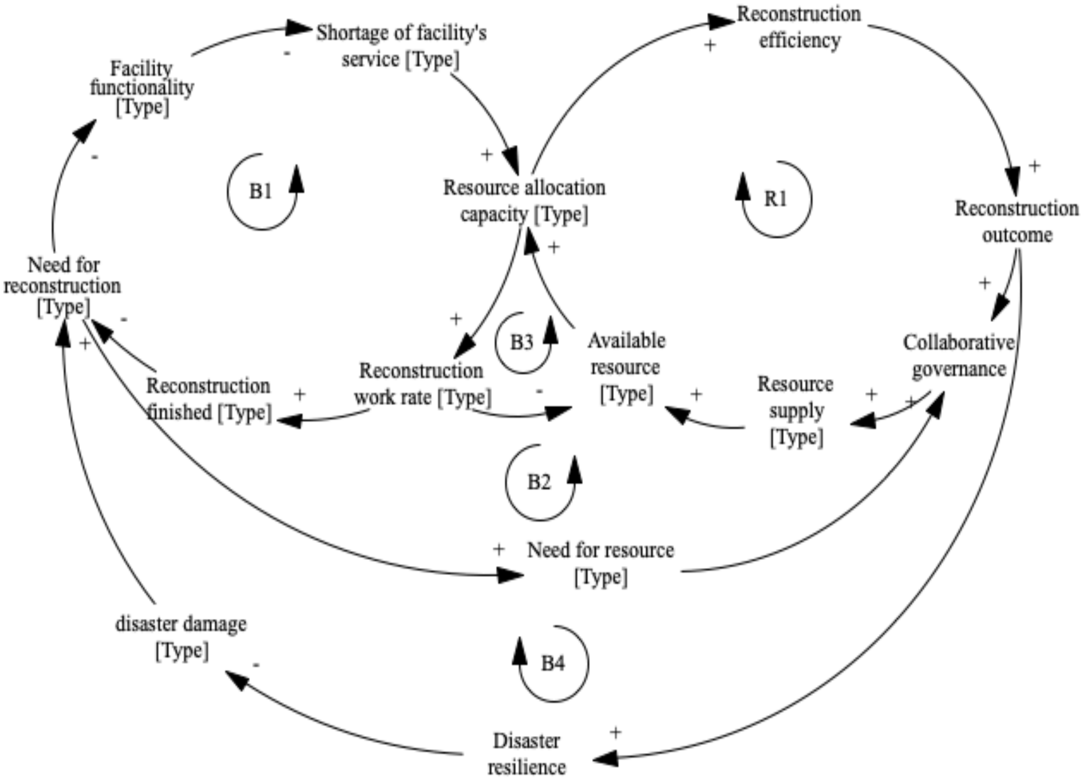


Figure 4.2 General causal loop diagrams: Post-disaster reconstruction and collaborative governance
(Adapted from Hwang et al., 2014)

Table 4.7 Variable classification based on types of infrastructures
(Adapted from Hwang et al., 2014)

Variable [type]	Reconstruction type	Function
Variable [G]	General infrastructure (e.g., residential and commercial building)	Residential and commercial service
Variable [C]	Critical infrastructure (e.g., school, hospital, power communication, …)	Public service
Variable [I]	Industrial infrastructure (e.g., industry, agriculture, tourism. …)	Industrial and economic service
Variable [T]	Transportation infrastructure (e.g., roadway, railroad, …)	Transportation service

In the process of reconstruction catastrophic disaster, those responding to emergencies in public sectors must support the recovery of the social infrastructure, such as construction and lifeline systems, and the economic restoration in stricken areas and the rehabilitation of victims' lives in the long term.

In this situation, for the public and private sectors, the commitment to collaboration is likely to drive organizational change and affect resource reallocation. The resources available to perform reconstruction works are limited because all kinds of overall damaged built environments require a substantial amount of budget, materials, personnel, skills and equipment. Resource problems can differ according to both the number of damaged facilities and the degree of such a damage. For instance, when a few facilities are completely destroyed, resources such as construction equipment are less limited because they are required by a few projects. On the contrary, when many facilities are damaged, and consequently, many projects simultaneously require restoration resources, resource problems can be more severe. Thus, the more established the collaboration system, the more opportunities for an exchange of the resources and information required in post-disaster reconstruction and recovery facilitation ("B1" loop in Figure 4.2). The maximum of available resource can boost the efficiency of resource allocation, and thus satisfy the real-time requirements of the system and accelerate the process of reconstruction. These excessive needs for resources continue until the reconstruction of the built environment is completed, although they can gradually be alleviated as the reconstruction operation progresses ("B2" loop in Figure 4.2). As the post-disaster reconstruction work needs to consume a large amount of resource for keeping performing different projects, this will reduce resource reserve ("B3" loop in Figure 4.2). By conducting reconstruction activities, the overall social and natural environment system in the disaster area will be recovered back to its original or better state. For example, the reconstruction operation, by reducing the disaster risk in the future, it has a positive impact on disaster resilience. With the improvement of disaster resilience, the ability of individuals, communities, organizations and states to adapt to and recover from disasters without compromising long-term prospects for development will increase. Therefore, less need for reconstruction will be needed in the future ("B4" loop in Figure 4.2).

From another point of view, a lack of resources for post-disaster housing reconstruction significantly limits the prospects for a successful recovery. As costs resulting from disasters continue to rise throughout the world, prudent allocation of limited government reconstruction resources becomes even more critical. Post-disaster resource availability determines the efficiency of resource allocation, which impacts on the capacity of the reconstruction practice. The efficiency of post-disaster reconstruction affects the achievement of reconstruction performance outcomes, including government credibility, the quality of public life, the images of enterprises and the social identity of social organizations. These reconstruction outcomes will affect the participants' commit to collaborative governance, subsequently it will contribute to supplying additional resources ("R1" loop in Figure 4.2).

Following Shoji and Toyota (2009), an understanding of interdependency among diverse functions of facilities/infrastructures is required to improve efficiency in recovering the daily lives of populations and the restoration process. To understand how different types of infrastructure change the post-disaster reconstruction activities and how this collaborative governance post-disaster reconstruction mode affects its environment system better, a detailed CLD is reported in Figure 4.3. In Figure 4.3, the reconstruction systems are separately built based on the type of infrastructure, including the subsystems of

- *general infrastructure reconstruction* [G] (shown as the orange loops);
- *critical infrastructure reconstruction* [C] (shown as the purple loops);
- *industrial infrastructure reconstruction* [I] (shown as the green loops);
- *transportation infrastructure reconstruction* [T] (shown as the black loops).

The subsystems are not isolated but interact with each other. For example, the reconstruction of transportation infrastructure could provide support for the delivery of resources, thereby affecting the resources allocation capacity in various subsystems.

The red loops in Figure 4.3 represent the collaborative governance among government, profit organizations, non-profit organizations and the public. Reconstruction performance outcomes are defined through quantitative indicators, including living standard, economic recovery, government credibility, cooperate image, the identity of social organizations. Government credibility, as the foundation of its

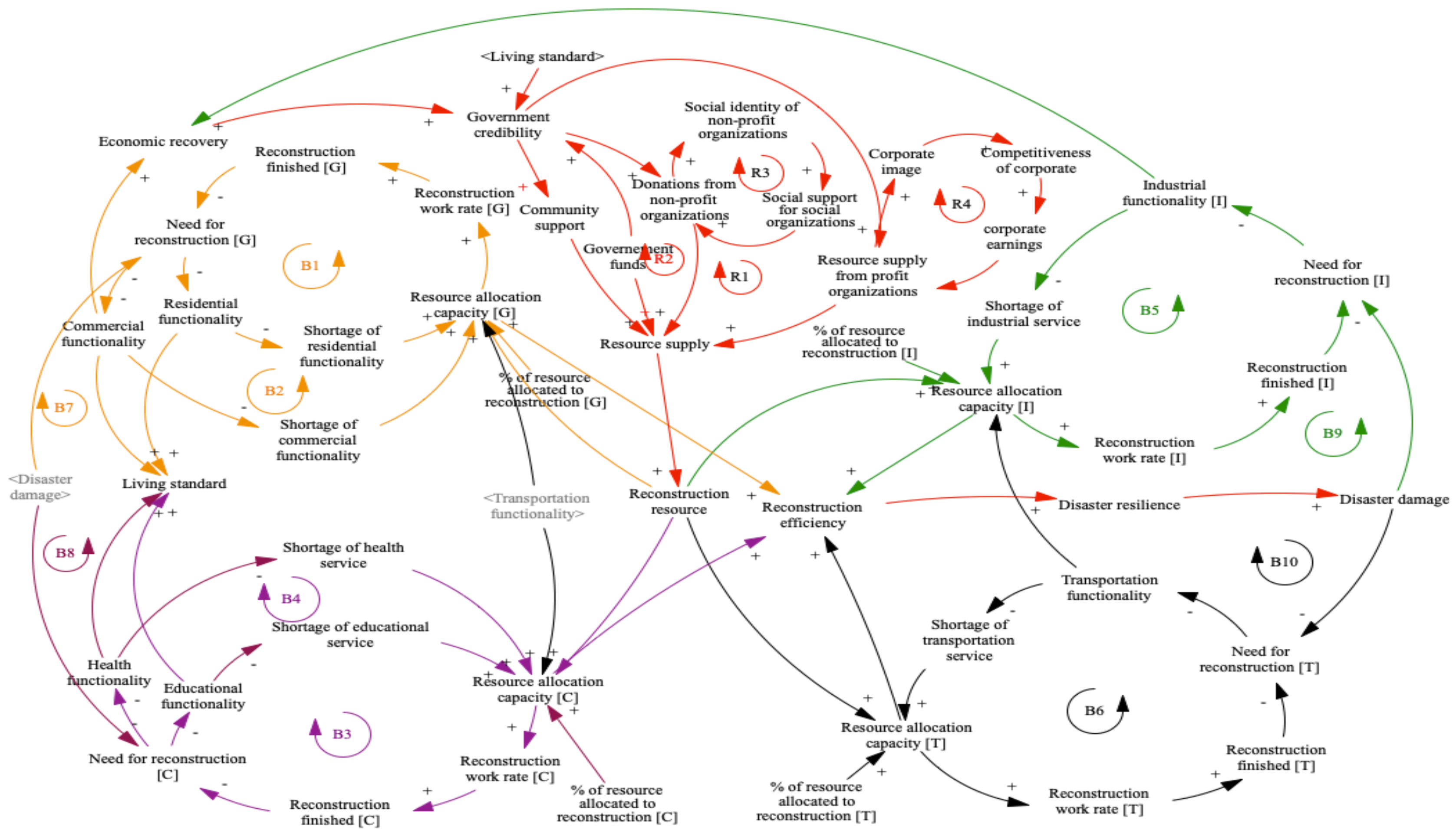


Figure 4.3 Detailed causal loop diagrams: Post-disaster reconstruction and collaborative governance

leadership, determines stakeholders' enthusiasm about the direction in which the government is leading the reconstruction process (Kouzes & Posner, 2011). Therefore, the higher the government credibility is, the higher the participants' enthusiasm will be. This would imply more resources provided by profit and non-profit organizations ("R1" and "R2" loop in Figure 4.3).

For-profit organizations, participation in post-disaster reconstruction could enhance their "Corporate image" of profit organizations. Corporate image refers to the immediate mental picture that audiences have of an organization. In other words, it indicates a value judgement about the company's attributes (Gray & Balmer, 1998).

The increase of corporate image will improve its competitiveness, thereby generating more benefits to profit organizations. Therefore, the profit organizations are more capable of supplying resource to post-disaster reconstruction ("R3" loop in Figure 4.3). Non-profit organizations, by providing assistance in post-disaster reconstruction, could improve their "Social identity". Social identity theory (Tajfel 1984) originated from the conviction that group membership can help people to instill meaning in social situations. Non-profit organizations could enhance their group's social status by collectively contributing in the post-disaster reconstruction (Turner & Oakes, 1986). Higher social identity helps non-profit organizations get more resource from their donors. As a consequence, non-profit organizations can assign more resources to the post-disaster reconstruction practice ("R4" loop in Figure 4.3).

The causal loop diagrams reported in figures 4.2 and 4.3, based on the principles of the system dynamics methodology, offer the basic information to design and build a full DPM chart. Figure 4.4 illustrates a generic DPM framework of the collaborative governance in the post-disaster reconstruction. It aims to show how the interaction among different stakeholders can improve the quality of life in the disaster region and the sustainable development of the local area. The figure illustrates six end-results (performance outputs and outcomes), namely the change in facility functionality, change in available resource, change in governance credibility, change in corporate image of profit-organizations, change in social identity of non-profit organizations and change in disaster resilience. These in turn are influenced by five performance drivers, including the resource allocation capacity, reconstruction efficiency, resource allocation efficiency, sustainable development of the disaster area and collaborative governance attractiveness.

The performance drivers shown in Figure 4.4 can be associated to two performance categories related with collaborative governance in post-disaster reconstruction:

- performance reflecting the role collaborative governance in the post-disaster reconstruction, such as the reconstruction efficiency, resource allocation capacity, resource allocation efficiency;
- performance reflecting the impact of reconstruction activities to different participants and the whole reconstruction, including the sustainable development of the disaster area and the attractiveness of collaborative governance.

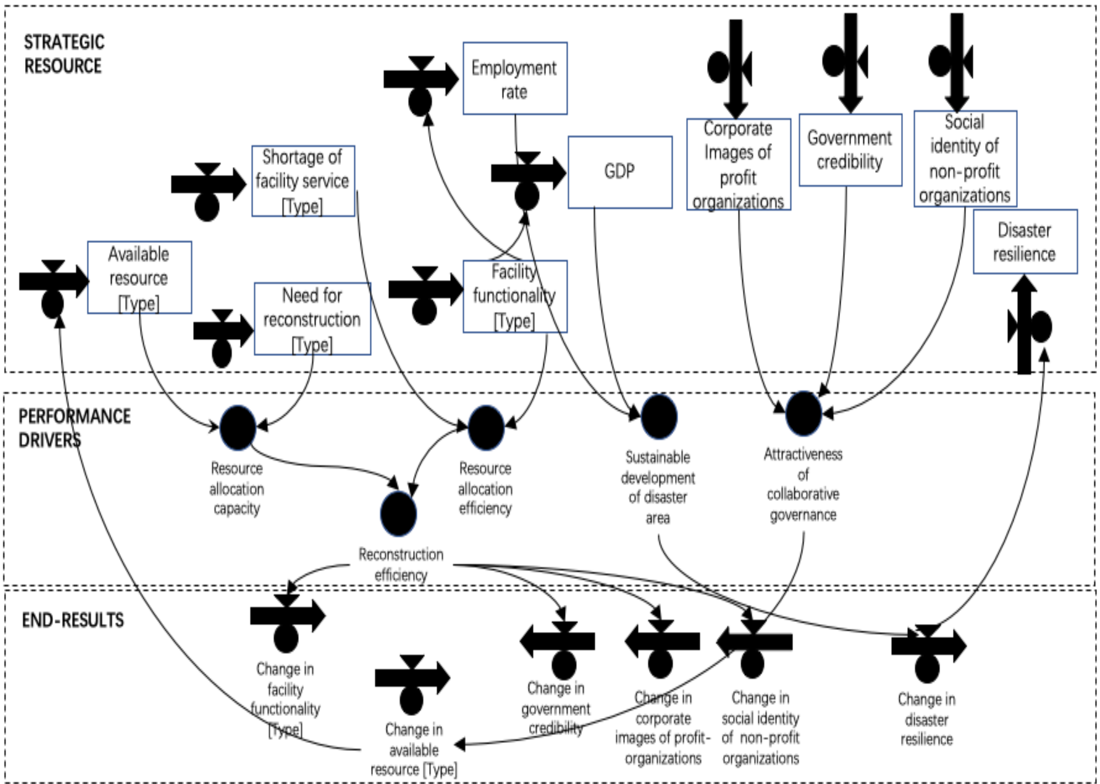


Figure 4.4 DPM chart portraying the relationship between collaborative governance and post-disaster reconstruction

The performance driver "Attractiveness of collaborative governance" is mostly related to the "attraction process" of getting multiple stakeholders interested in contributing to post-disaster reconstruction. To boost this attractiveness, public sector organizations must design conditions, promote values, and create incentives that would enable and induce stakeholders to pursue their goals. To this end, as depicted in Figure 4.4, this may require policy-makers to consider the different objectives for each stakeholder, such as the improvement of government credibility, the improvement of enterprises' images, and the improvement of social organizations' social identify. Through the incentives, more participants will be attracted to become involved in the resource supply of post-disaster reconstruction.

The performance driver "Resource allocation capacity" is the ratio between total available resource and total resource needed by reconstruction. It represents to what extent the need for reconstruction is meet. While the "Resource allocation efficiency" performance driver represents whether a resource is wasted or not in reconstructing. When resource allocation capacity and resource allocation efficiency rise, they will increase the reconstruction efficiency (the fourth performance driver), trigger further government credibility and stakeholders' commitment to co-production.

The last performance driver is "Sustainable development of the disaster area". Different dimensions can be used to gauge this driver, such as, the economic development, adjustment of the industrial structure, improvement of the employment structure and the increase of living quality. The sustainable development of the disaster area can be calculated by comparing the relative indexes before and after the reconstruction. When sustainable development of disaster area rises, it will increase this ratio, which in turn will improve the system's disaster resilience in the future. The increase in disaster resilience implies that there would be fewer damages when the next disaster occurs. Therefore, the need for reconstruction will also be reduced in the future.

A few potentially powerful reinforcing loops can trigger further the development of such a collaboration, particularly when innovative new co-production initiatives (as a strategic resource) become successfully (Bianchi, 2016). For example, strategic resource, such as corporate images of profit organizations, government credibility and non-profit organizations social identity may increase the credibility of co-production and further boost the willingness of other stakeholders to participate in co-production initiatives. The DPM model in Figure 4.4 shows an aggregate analysis of the primary relationships in post-disaster reconstruction. When such a level of collaboration is studied in more detail, co-production processes can refer to co-design of reconstruction plan, co-supply and co-delivery of resources, co-building, etc. Each of these collaborations entail a different process by which stakeholder's involvement can make post-reconstruction more cost effective and more closely aligned to the desired outcomes.

Figure 4.4 depicts an aggregate and qualitative DPM model. As such, it can add value to post-reconstruction policy design, since it can support communication and coordination among different stakeholders. In particular, identifying the relevant variables related to the three different level of performance (strategic resources, drivers and end-results), and framing the hypothesized causal pathways leading over time to changes in the performance drivers and the end results, appears critically important. In fact, it can contribute to support decision makers in identifying interactive feedback loops, which could have been previously neglected or misunderstood (Bianchi, 2016).

Such insights can be used to build an "insight" (i.e., generic) model or a "detailed customized" model to assess alternative decision sets in different scenarios. Though such a generic model is "not appropriate for solving specific problems. . . . . . [it] can improve policy making in general by upgrading the quality of a manager's mental models" (Paich, 1985, p. 130).

System dynamics modeling at the "insight" level is an established practice used to create a general understanding of the investigated phenomenon and to offer simplified graphic demonstration (Warren, 2005; Winch & Joyce, 2006). It should not be confused with quantitative parameter-setting modeling, which sometimes occurs as a further stage of analysis. The point of such modeling is to identify areas where dynamic factors (i.e., those with feedback effects within the system) may have important influence on the way a given phenomenon behaves over time.

Therefore, a detailed stock-and-flow diagram was constructed based on the casual loop diagram and DPM diagram, and equations and parameters were entered for all variables. The stock-and-flow diagram thus represents the system of hypothesized causal relationships in the system (i.e. the causal factors that determine the performance outcomes of the post-disaster reconstruction). SD models are broken up into a series of "stocks" (a terminology used in system dynamics that refers to some quantity that can accumulate, e.g., need for reconstruction and available resource in region) and "flows" (transition rates between stocks, e.g., damage generation that describes the damage caused by disaster), and are especially appropriate for systems that contain positive or negative feedback relationships, which lead to changes in the behavior of the investigated key variables (e.g., increase of reconstruction) over time.

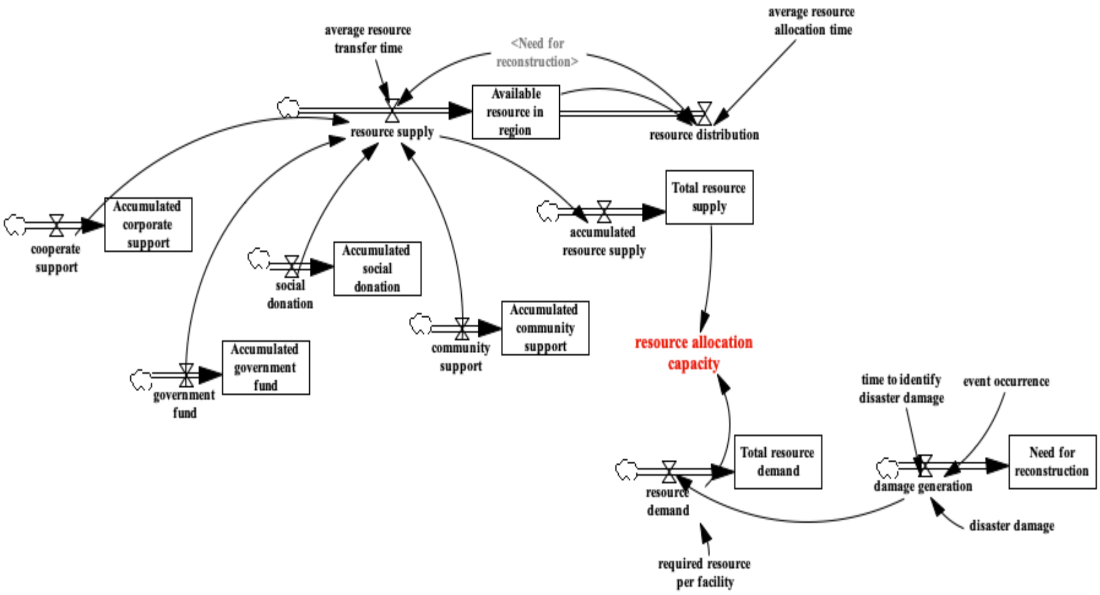


Figure 4.5 The stock and flow diagram model of the resource allocation capacity

By using the findings from the causal loop diagrams and the DPM chart, and existing researches a simulation model was built.

A key performance driver of the collaborative governance outcome is the resource allocation capacity (RAC). Such a variable is the ratio of the total available resource over the total resource demand (Eq. 1). This index indicates that the more resources are supplied, the higher the resource allocation capacity is. On the other hand, the more resources are demanded, the lower resource allocation capacity will result. As the ratio approaches to one, the system will get more resistant to failure. RAC is considered as one key performance driver of the end-result outcome for collaborative governance.

$$RAC = RS/RD \qquad (1)$$

RAC	Index of resource allocation capacity
RS	Total resource supply
RD	Total resource demand

As depicted in Figure 4.5, the RAC is influenced by two factors: “Total resource supply” and “Total resource demand”. The Total resource supply is affected by “resource supply” while Total resource demand is originally affected by the “disaster damage”. Referring to what has been discussed in the part of collaborative governance in post-disaster reconstruction, the source of Total resource supply comes from four stakeholders, which are the governments, profit-organizations, non-profit organizations and the public. Correspondingly, the resources supplied by these multi-stakeholders are named government funds, cooperate supports, social donations and community supports.

Three dynamic mechanisms are working to affect the “Total resource supply”. The first mechanism is responsible for RAC (in Figure 4.6). In this study, it is assumed that the RAC has a negative impact on stakeholders’ resource supply. When stakeholders perceive there is high demand and/or low resources endowment, they prefer to take active actions to participate in resources supply practice. With the time increasing, RAC grows gradually and tends to 1.

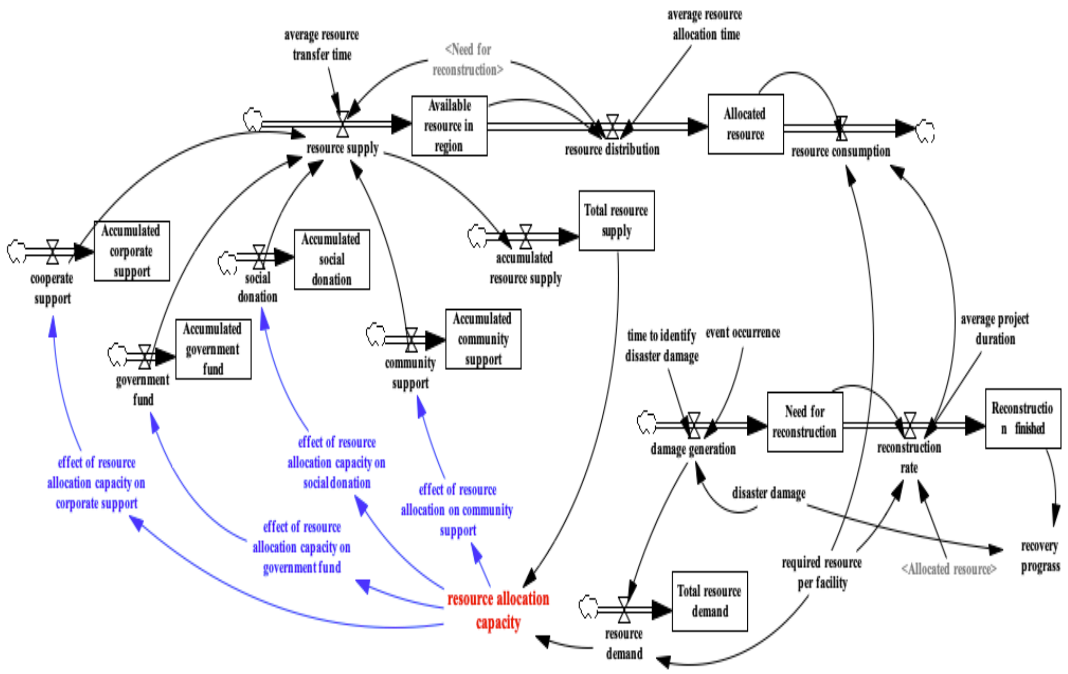


Figure 4.6 The stock and flow diagram model—the mechanism of resource supply affected by resource allocation capacity

The second mechanism affecting “Total resource supply” is government credibility.

Government credibility reflects the public's trust on government. If the public believes or trusts government more, they will support the government and actively engage in the post-disaster reconstruction (Hong et al., 2011). As an important indicator of government leadership, government credibility, to a large extent, determines the effects of collaborative governance in post-disaster reconstruction. This variable has a positive impact on the resource supply from different stakeholders (in Figure 4.7). Higher government credibility strengthens trust in government, thus contributing to the stakeholders' support to post-disaster reconstruction. Government credibility is susceptible to change according to government funds, citizen satisfaction and economic recovery depicted in Figure 4.8. Increase in government funds, citizen satisfaction and economic recovery could also promote the growth of government credibility.

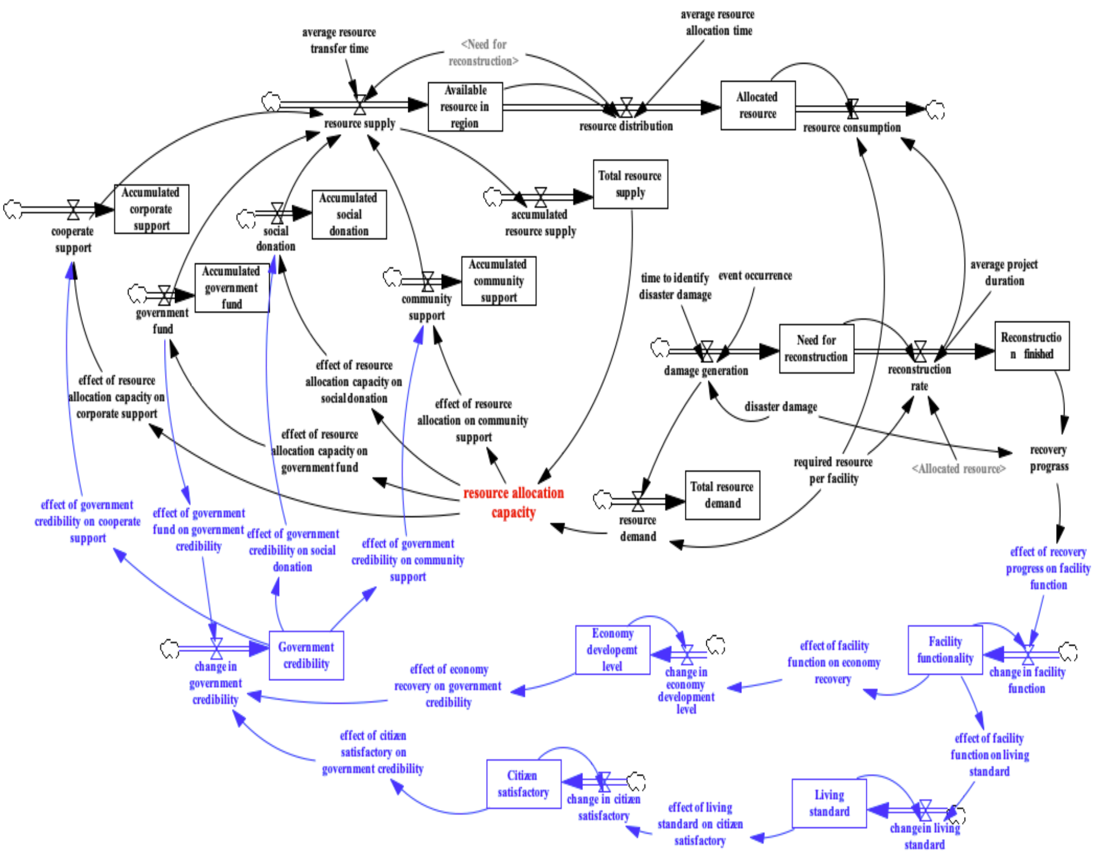


Figure 4.7 The stock and flow diagram model—the mechanism of resource supply affected by government credibility

The third mechanism which affects the "Total resource supply" is the stakeholders' resource supply capacity. It includes three parts:

1) Resource supply capacity of profit organizations. Participation in post-disaster reconstruction could enhance “Corporate image” of profit organizations. The increase in the corporate image will improve its competitiveness, which will bring more benefit to profit organizations. Therefore, profit organizations will be more capable of supplying resource to post-disaster reconstruction.

2) Resource supply capacity of non-profit organizations. Providing assistance for post-disaster reconstruction, resource supply capacity of non-profit organizations could improve non-profit organizations “Social identity”. Higher society identify helps non-profit organizations to get more resources from their donors. Consequently, non-profit organizations can assign more resources to the post-disaster reconstruction practice.

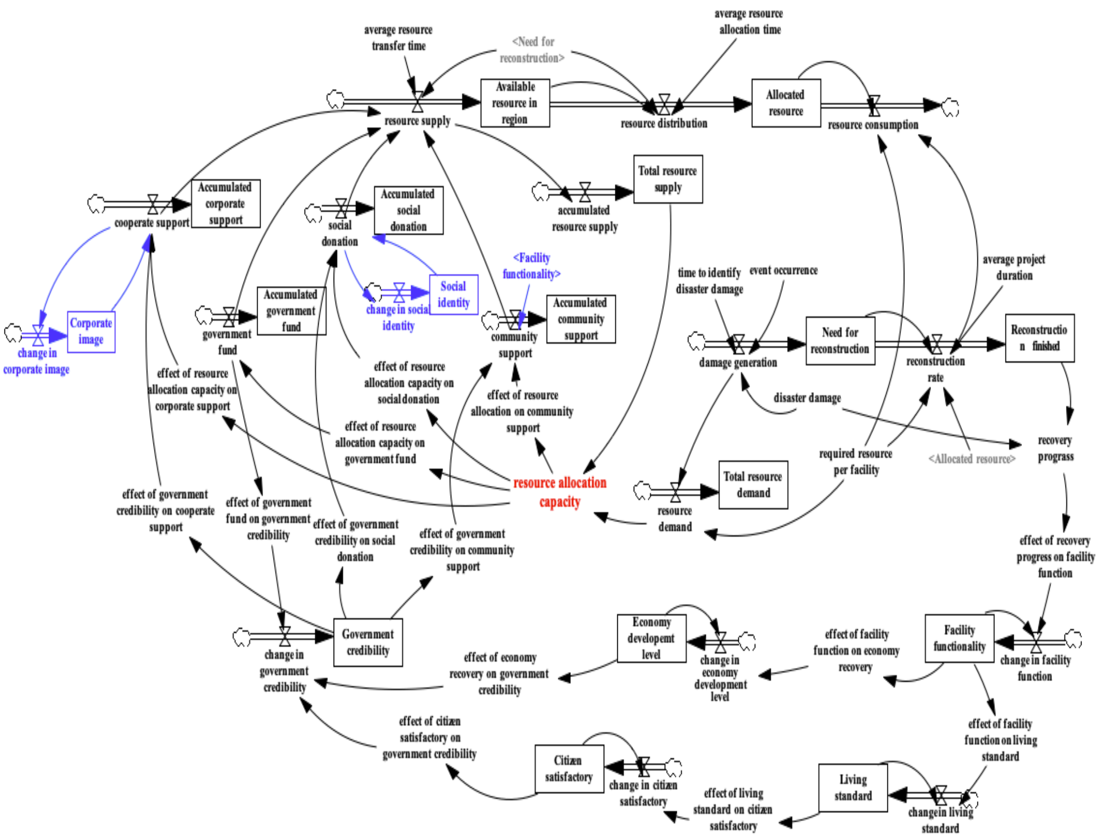


Figure 4.8 The stock and flow diagram model—the mechanism of resource supply affected by stakeholders’ resource supply capacity

3) Resource supply capacity of communities. Disasters may have a devastating impact on communities and their residents (Preiser & Vischer, 2005). At the early period, the resource availability in communities may result limited. Therefore, with the

restore of "facility functionality", services provided by different infrastructures will support communities to recover from the effects of disasters. This will help communities creating better use of resources to rebuild the damaged area.

(3) Assumptions and initial value

It should be noted that in order to execute the final SD model depicted in Figure 4.8, it is necessary to add more auxiliary variables and input parameters. The list of the variables in the model is given in Appendix A. Simulation models also requires to define initial values to variables, such as stocks, inputs and policy on which decision-makers can act on. The initial values for key stock variables and input parameters are reported in Tables 4.2 and 4.3.

Table 4.8 Initial values of the model stock variables

Variable	Value scale	Initial value	Remarks
Facility functionality	0-1	0.2	Assumed capacity of infrastructures reduces to 20% of its full facility functionality after the disaster.
Living standard	0-1	0.2	Assumed the living standard reduces to 20% of its pre-earthquake level.
Citizen satisfaction	0-1	0.5	Assumed citizen satisfaction reduces to 50% of its pre-earthquake level.
Economy development level	0-1	0.5	Assumed economy development level reduces to 50% of its pre-earthquake state.
Government credibility	0-1	0.5	Assumed government credibility is 0.5 at the start of post-disaster reconstruction.
Corporate image	0-1	0.5	Assumed corporate image of profit organizations is 0.5 at the start of post-disaster reconstruction.
Social identity	0-1	0.5	Assumed social identity of non-profit organizations is 0.5 at the start of post-disaster reconstruction.

Table 4.9 Sample input functions

Function
Damage generation (Facility/month) = SMOOTH3 (disaster damage*event occurrence, time to identify disaster damage)
Reconstruction rate (Facility/month) = IF THEN ELSE (Need for reconstruction>0, MAX (Allocated resource/average project duration,0), 0)
Recovery progress = Reconstruction finished/disaster damage
Total resource need (Resource) = disaster damage*required resource per facility
Resource supply (Resource/month) = IF THEN ELSE (Need for reconstruction>0, (cooperate support + government fund + community support + social donation)/resource transfer time,0)
Cooperate support (Resource/month) = average cooperate support*effect of resource allocation capacity on cooperate support*effect of government credibility on cooperate support*effect of cooperate image on cooperate support
Government fund (Resource/month) = average government fund*effect of resource allocation capacity on government fund
Community support (Resource/month) = average community support*Facility functionality*effect of government credibility on community support
Social donation (Resource/month) = average social donation*effect of social identify on social donation*effect of resource allocation capacity on social donation*effect of government credibility on social donation
Resource distribution = IF THEN ELSE (Accumulated needs for reconstruction>0, MAX (Available resource in region/average distribution time/facility functionality,0), 0)

There are also a number of main assumptions embedded in the model, such as:

- there's no secondary disasters；
- there's no difference in the categories of resource；
- the information in resource supply chain is symmetrical. This means the supply will not exceed demand；
- the resource supply is unlimited. This means all the stakeholders would constantly provide resources until post-disaster reconstruction is completed;
- the reconstruction operations would end in five years.

4.4.2 Model validation

System dynamics models need to be tested and validated before being used. In this chapter, verification has been carried out on both the "structure" and the "behavior" of the model (Saysel et al., 2002). To verify the model structure; at first, its boundaries have been modified to include all indigenous variables. Secondly, the test of extreme values was carried out to check for the logical connections among variables.

The model's behavior has been verified against variables associated to the "Resource allocation capacity" and the "Recovery progress" (Figure 4.9). "Resource allocation capacity"increases with logarithmic growth curve, which is in line with reality. Stakeholders often invest more resources in the early stage of the post-disaster reconstruction due to the urgency of damage restoration. Then, the resources supply will decrease because of the reduction in the importance of reconstruction and stakeholders' attention. The "Recovery progress" has been considered as a function of the ratio of "Reconstruction finished" to "Disaster manage". In the early reconstruction phase, as the reconstruction rate is restricted by the relevant supporting infrastructures (e.g., transportation infrastructures), the recovery progress experiences a slow growth. With the restoration of facility functionality, recovery progress will accelerate. In the late period, however, the reconstruction progress will slow down again, as most of the reconstruction works have been finished. Thus, the function shows an S-shaped growth curve (Murao & Nakazato, 2010). It depicts an increasing trend and leveling off as the ratio approaches one.

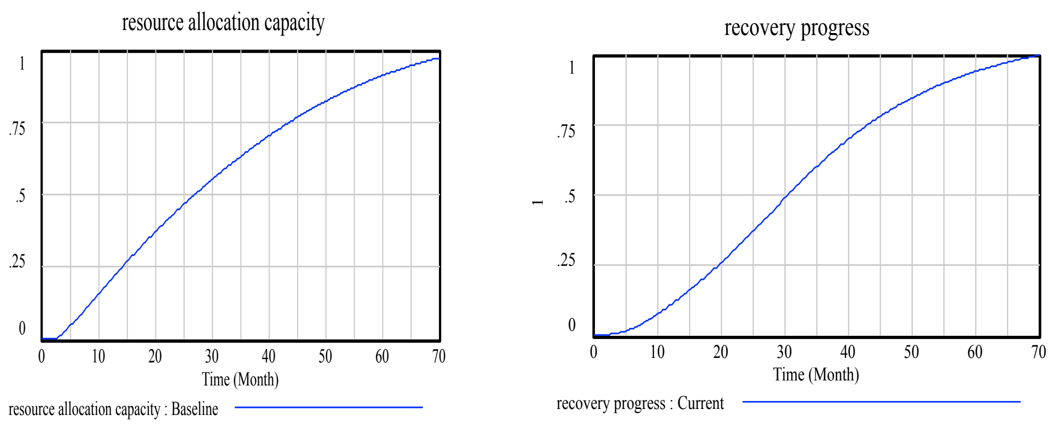


Figure 4.9 Results of behavior test

In the model, some relationships such as “Effect of recovery progress on facility functionality”, “Effect of facility functionality on living standard”, and “Effect of living standard on citizen satisfactory”, “Effect of citizen satisfactory on government credibility” and “Effect of government credibility on social donation” have been introduced as graph function (or look up tables) and sensitivity analysis tests have been carried out. Such tests showed that the “Recovery progress” was not so sensitive to the values of those functions; instead, the functions shape were more important. In Figure 4.10 the results of the sensitivity tests are documented for the graph function of “Effect of citizen satisfactory on government credibility” against “Recovery progress”.

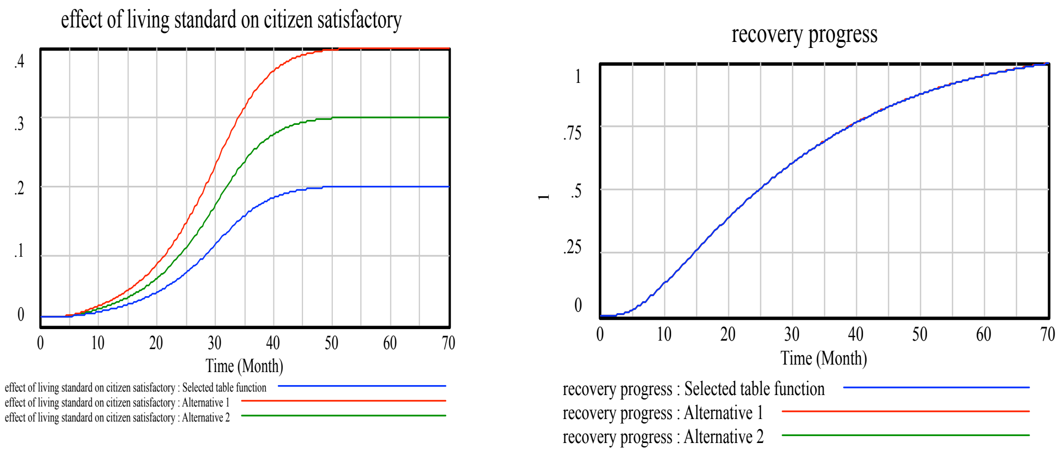


Figure 4.10 Temple of sensitivity analysis on the model look up table functions

4.5 Model Simulation and policy analysis

4.5.1 Model simulation

The model covers a simulation period of five years, while the time unit is expressed in months. Simulation results of the effects of collaborative governance on post-disaster reconstruction performance are depicted in Figure 4.11.

As one can observe, the trends of living standard, economic development level, government credibility and citizen satisfaction increase showing an S-shaped growth curve. These social-economic performance indicators slowly grow at the start of post-disaster reconstruction. In the middle of the reconstruction, they raise to one. This means that the effects of collaborative governance are now fully exploited. Variations of corporate image and social identity experience a logarithmic trend. These simulation results show that the corporate image of profit organizations and the social identity of non-profit organizations often grow faster in the early stage of the reconstruction. Thus, it will be of interest to encourage profit and non-profit organizations to participate in the post-disaster reconstruction practice as soon as possible.

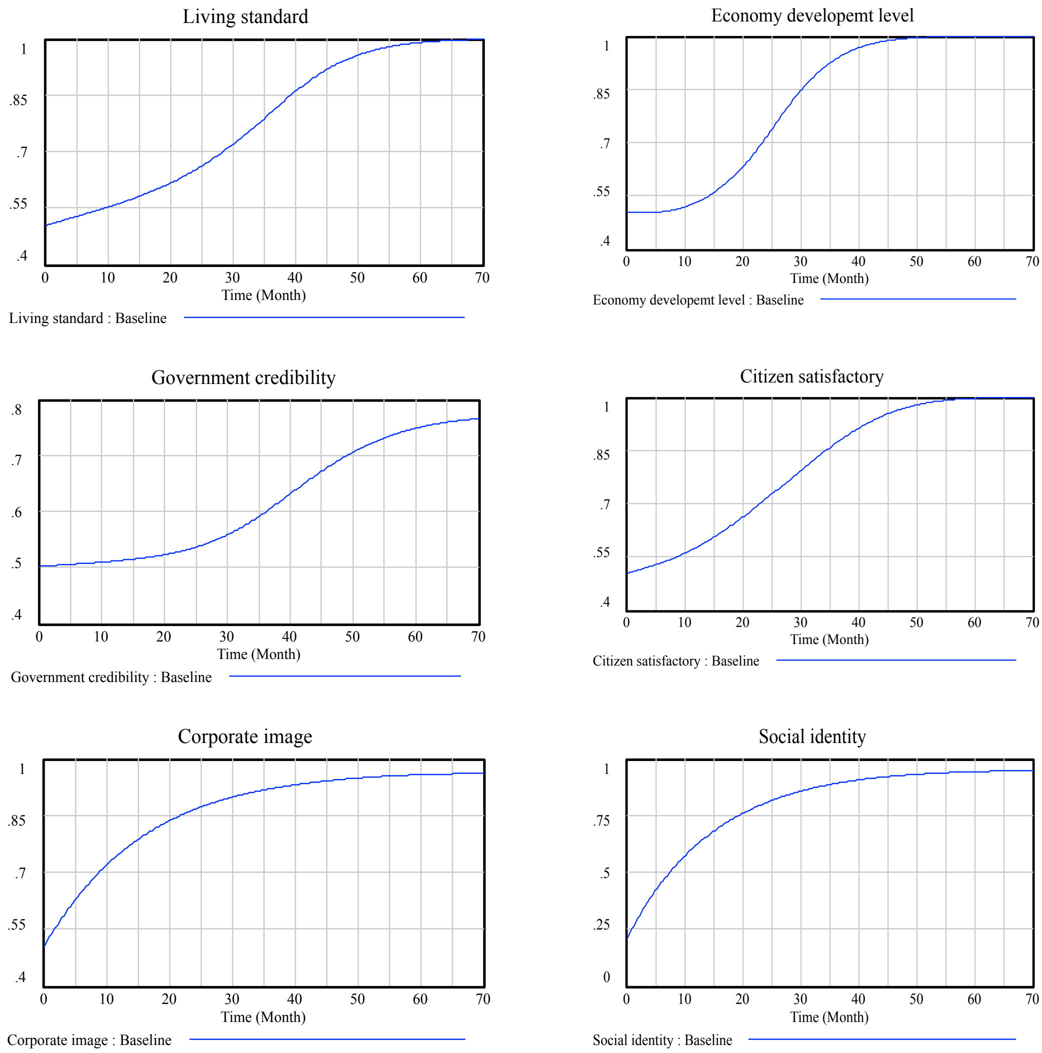


Figure 4.113 Simulation results of key variables in this collaborative governance system

4.5.2 Scenarios and polices

This section shows the results of five alternative scenarios generated by the adoption of different decisions related to the policy interventions. The policies imposed in the simulation runs are listed in Table 4.4.

Table 4.4 Policies set in the simulation model

Scenario No.	Policy lever	Initial value	Policy parameter
1	Average government fund	7000 R[a]	10350 R
2	Government credibility	0.5	0.75
3	Average resource transfer time	1 M[b]	0.5 M
4	Average resource allocation time	1 M	0.5 M
5	Facility functionality	0.2	0.4

[a]R: Resource, the unit for resource.
[b]M: Month, time unit.

Simulation results of key variables in this collaborative governance setting are shown in Figure 4.12.

In the first scenario (S1) to assume a direct control on resource supply in post-disaster reconstruction, it is assumed a high government fund policy. As it can be observed from Figure 4.12, this policy can improve resource allocation capacity and accelerate recovery progress. It also has a positive impact on living standard and economic development level. However, from a long-term perspective, it is not conducive to the improvement of government credibility. This is because government funds will reduce rapidly if the investments needed are too high, mainly, at the early stage of post-disaster reconstruction. It means that the effects of such a control policy on government funds may contribute to reduce government credibility. In addition, it has a negative impact on the corporate image of profit organizations and the social identity of non-profit organizations. This phenomenon can be explained as consequence of the excessive investments from government, which may suppress the participation of profit and non-profit organizations. Therefore, a high government fund policy reduces the effect of collaborative governance in a long term.

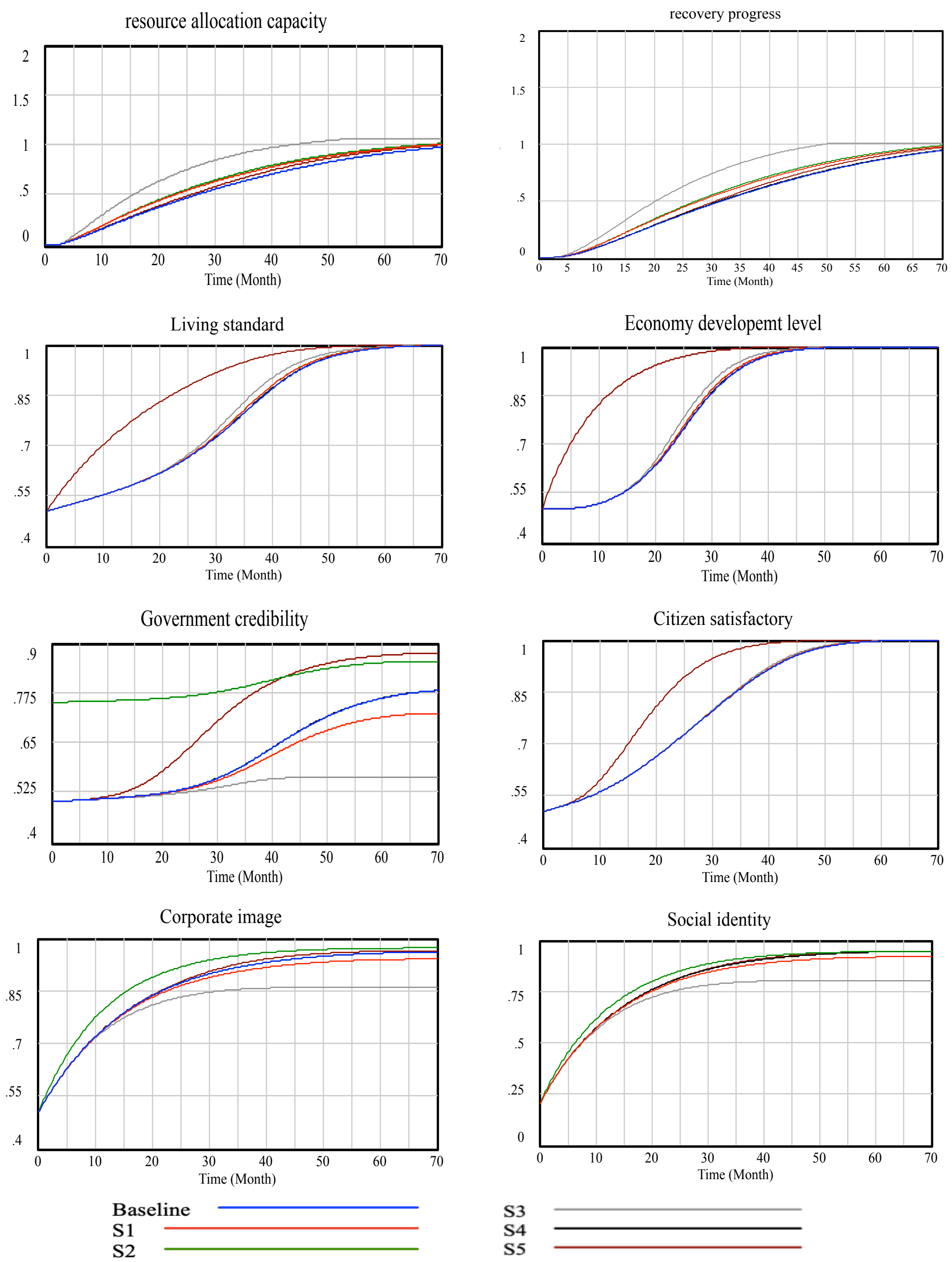


Figure 4.114 Simulation results of key variables in this collaborative governance system according to different policies

The second scenario (S2) intends to increase the government credibility, thereby improving government leadership in the collaborative governance of post-disaster reconstruction. Figure 4.12 shows that the resource allocation capacity and recovery progress increase to a large extent. In particular, this policy has a significant positive effect on the corporate image of profit organizations and the social identity of non-profit organizations comparing with other polices. This simulation result can be used to support the assumption that effective collaborative governance is helpful to improve post-disaster reconstruction performance.

The third scenario (S3) examines the effect of increasing the speed at which resources are supplied. In this scenario, it has been assumed that the resources supplied by multiple stakeholders can be available to be used in a short period of time (e.g., half of a month). This policy can be very influential to foster the resource allocation capacity and the recovery progress. Comparing with other scenarios, S3 can shorten the duration of post-disaster reconstruction phase. At the same time, living standard and economic development level can recover more quickly. But in a long run, this policy severely restricts the improvement of government credibility, corporate image of profit organizations and social identity of non-profit organizations. The reason is that stakeholders will reduce their support for the reconstruction, when they perceive the gap between resource supply and demand is small.

The fourth scenario (S4) is similar to the S3, but it increases the speed at which resources are distributed. Since the reconstruction rate is mainly affected by the resource supply through a collaborative governance frame, this policy has limited impact on the post-disaster reconstruction practice.

The fifth scenario (S5) aims to examine the effect of facility functionality on the post-disaster reconstruction. It assumes that the community's resistance is higher than before, and the disaster damage on facilities is very low. These simulation results show that, even if there is not an improvement in resource allocation capacity and recovery progress, all variables, such as government credibility, living standard, economic development and citizen satisfaction experience a massive growth. This policy works better on the social and economic reconstruction.

4.6 Discussion and conclusions

This chapter outlines the results of the combined use of collaborative governance in post-disaster reconstruction and SD modelling. It has been assumed that a better understanding of the collaborative governance in post-disaster reconstruction can support decision makers in the effective implementation of reconstruction practices (e.g., reconstruction progress, economic recovery) and in the improvement of social-economic indicators (e.g., government credibility, citizen satisfaction).

The interactions of multi-stakeholders in post-disaster reconstruction were investigated and made explicit in a SD simulation model. The dynamic of resource supply, reconstruction, resource allocation, and collaborative governance among the government, profit and non-profit organizations, and the public were modeled. The validity of the SD model built was validated using several sensitivity tests. The collaboration among multiple stakeholders has shown to be critical for the improvement of resource allocation capacity and post-disaster reconstruction performance. Government credibility also demonstrated to play an important role in the successful implementation of a collaborative governance approach.

Scenarios findings and lessons learned from policy analysis can be used to support specific guidelines for future post-disaster reconstruction practices.

Although this study results offer new knowledge on the dynamic and complex effects of collaborative governance on post-reconstruction practices, further researches are needed to investigate different contexts and other possible policies. For instance, fiscal and taxation policies to stimulate collaborative governance in post-disaster reconstruction.

Therefore, further research is necessary to develop more applied knowledge on this general model and its effectiveness in supporting collaborative governance in post-disaster reconstruction. To provide empirical evidences on the SD model design and implementation, in the next chapter, a case-study of collaborative governance in Wenchuan Earthquake reconstruction is illustrated and discussed.

Chapter 5 Is "Paired Assistance Policy" reconstruction mode more efficient than traditional mode? A simulation approach to understanding collaborative governance in post-Wenchuan Earthquake reconstruction

5.1 Introduction

This chapter moves forward the study presented in chapter 4; it applies the Dynamic Performance Management (DPM) chart and the general System Dynamics (SD) model of the collaborative governance in post-disaster reconstruction to a real post-disaster reconstruction case: the Wenchuan Earthquake. The recovery process following the 2008 Wenchuan Earthquake in China took more than 10 years. Over this period, 41 severely damaged counties and county-level cities in Sichuan, Shaanxi, and Gansu provinces exceeded their economic, social, ecological, and cultural status compared to the period before the earthquake hit (Xinhua News Agency, 2018). The Wenchuan Earthquake offers an illuminating case study for better understanding the dynamic collaborative governance in post-disaster reconstruction (Guo & Kapucu, 2015; Liu et al., 2017). The impacts of the Wenchuan Earthquake and the related lessons are expected to influence the way international practitioners deal with disaster reconstruction in the future.

For a long time, the centralized Chinese administrative system has been particularly active in assisting local disaster reconstructions. More generally, China is a nation of a stable and strong government, moderate markets, and weak society (Nonini, 2008; Zhou & Tao, 2009; Du & Ling, 2016). As a result, disaster reconstructions usually involve substantial governmental participation (Lu & Han, 2018). For example, the Chinese central government initiated the Paired Assistance Policy (PAP) as the core policy mechanism for recovery from the Wenchuan Earthquake. Under this particular PAP, the central government paired 20 economically developed provinces or major cities with provincial status with 24 counties or county-level cities in the disaster-affected areas. For three years following the disaster, the developed provinces were required to provide more than 1% of their fiscal revenue to their corresponding partner through financial support and material resources. Such a command-and-control policy approach is the result of the political pressure expressed by the central government, which could be labelled “campaign-style governance” (Lu & Xue, 2016). In the long run, however, the political mobilization associated with this type of command-and-control was only the beginning of the post-disaster recovery process following the Wenchuan Earthquake. With the gradual evolution of the recovery work and the development of both vertical and horizontal intergovernmental relationships, the collaborative governance across the central and local governments, profit and non-profit organizations and the public could not be assumed to be constant (Tang, 2019).

To better gauge and explore the characteristics of collaborative governance in post-disaster reconstruction, in this chapter we argue that post-disaster recovery of the Wenchuan Earthquake needs to be understood not only in terms of paired assistance under political mobilization, but also as a model of collaborative networks that includes multi-stakeholders and vertical and horizontal governmental cooperation, which occurs through dynamic, complex, and long-term evolutionary processes.

To analyze these processes, the effect of policy incentives on collaborative governance is considered based on the analysis of the DPM chart and general SD model previously discussed in former chapter. In particular, this session analyses the effectiveness of governmental plans and related implications, on the reconstruction work progress and the collaborative governance among different participants (see Figure 5.1). Figure 5.1 aims to enrich the outcome-oriented view of the DPM chart, with a deeper understanding how reconstruction processes and related functionalities impact on outcomes in a real case. This chapter seeks to answer the following questions:

1. What is the PAP collaborative governance reconstruction mode?
2. How to illustrate the PAP collaborative governance reconstruction mode through a system dynamics approach?
3. Is the PAP reconstruction mode more efficient than the traditional mode?
4. What are the enlightenments of PAP collaborative governance reconstruction mode?

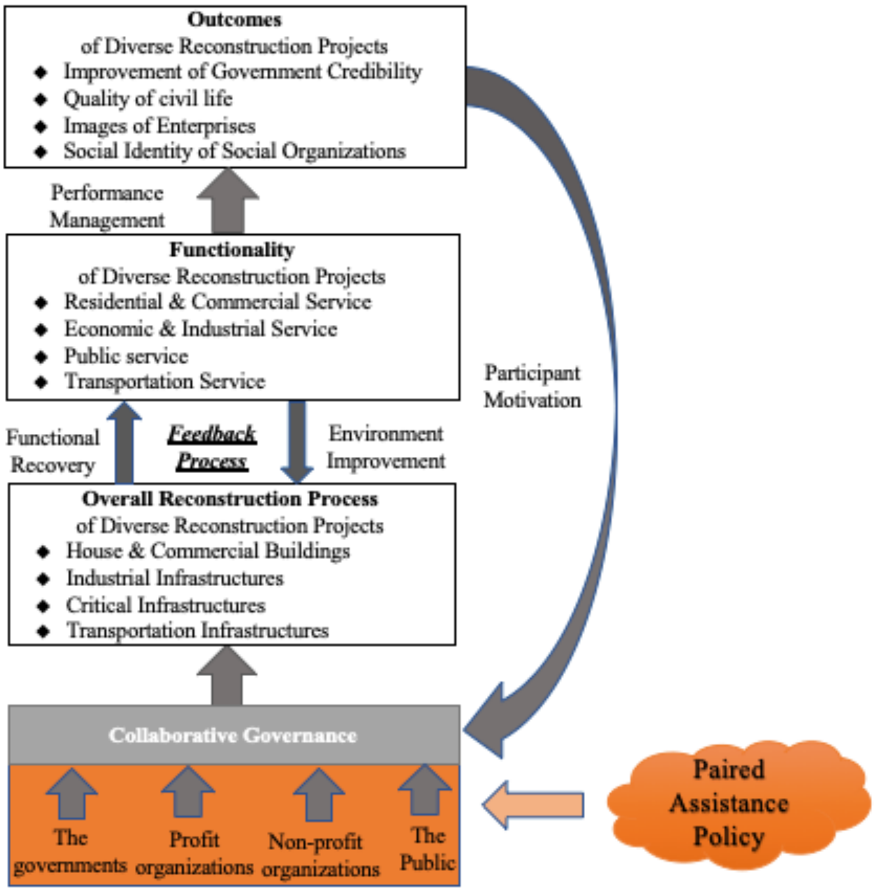


Figure 5.1 Collaborative governance in the post-disaster reconstruction of Wenchuan earthquake

The chapter is structured as follows. Firstly, it introduces the research background of this study. Session 2 conducts an overview of the post-Wenchuan Earthquake recovery master plan, the innovative PAP and the reconstruction practice in Sichuan province. In session 3, a concept model and a DPM framework are built to help understanding the effect of PAP on the collaborative governance in post-disaster reconstruction. Section 4 includes the description of the SD stock and flow model structure and simulation results of five alternative scenarios. Section 5 discusses the main results of this research. Section 6 provides concluding remarks and recommendations.

5.2 Case study

Sichuan earthquake, also known as Wenchuan Earthquake, Great Wenchuan Earthquake, Chinese Wenchuan dizhen or Wenchuan Da Dizhen, is a massive and enormous devastating earthquake occurred in the mountainous central region of the Sichuan province in southwestern China on May 12, 2008. The epicenter of the magnitude-7.9 quake (measured as magnitude 8.0 by the Chinese authority) was located near the city of Dujiangyan, about 50 miles (80 km) west-northwest of Chengdu, the provincial capital, at a depth of 11.8 miles (19 km) below the surface (Figure 5.2).

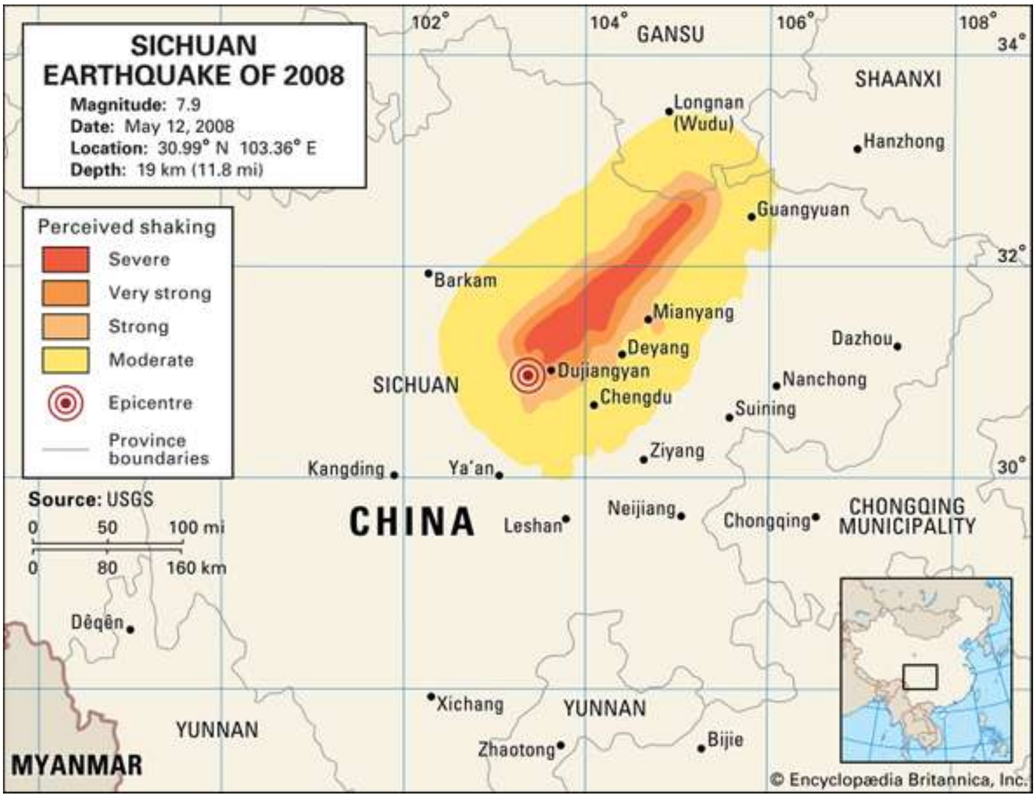


Figure 5.2 Map of Sichuan province, China, depicting the intensity of the shaking caused by the 2008 Wenchuan Earthquake

(Encyclopeadia Birtannica, Inc,)

The quake was caused by the collision of the Indian-Australian and Eurasian plates along the 155-mile- (249-km-) long Longmenshan Fault, a thrust fault in which the stresses produced by the northward-moving Indian-Australian plate shifted a portion of the Plateau of Tibet eastward. Compressional forces brought on by this shift sheared the ground in two locations along the fault, thrusting the ground upward by approximately 29 feet (about 9 meters) in some places. Numerous aftershocks occurred in the days, months, and years that followed, including a magnitude-5.0 event that struck Chengdu in May 2010. The Longmenshan Fault runs southwest to northeast along the eastern side of the Longmen Mountains (Longmen Shan) and separates the Plateau of Tibet from the flat Sichuan Basin.

The earthquake and numerous aftershocks caused secondary disasters such as landslides, avalanches, debris flow, and formation of barrier lakes (Shi et al., 2010). As one of the most damaging catastrophes in contemporary China, the earthquake resulted in 69,227 deaths, 374,643 injuries, 17,923 missing, and an estimated direct economic loss of 845.2 billion RMB, equivalent to US $ 120.2 billion (State Council of the PRC, 2008b). It affected life of more than 120 million people, left 5 million people homeless, and caused extensive damages to the economy and local critical infrastructures. Housing damages took the most part of the losses. Particularly, urban and rural houses accounted for 27.4% of the total number, while damaged schools, hospitals and other non-residential housing recorded another 20.4% (Li et al., 2019).

As the most devastating disaster in China's recent history, the Wenchuan Earthquake meets Quarantelli's (1999) six characteristics of a catastrophe: serious damage to most community structures, local officials' inability to work as usual, neighboring communities unable to offer help, interruption of most communities' daily functions, attraction of wide attention from public media, and a significant political arena. Such natural catastrophes render self-help and mutual assistance from neighboring communities impossible. The reconstruction of Wenchuan Earthquake brought unprecedented challenged opportunities to policymakers, researchers, and practitioners.

5.2.1 Overview of post-Wenchuan Earthquake recovery master plan

On June 8, 2008, the Chinese State Council approved the Regulations on Post-Wenchuan Earthquake Recovery, the first intervention of this type formulated for disaster recovery in China. On September 19, 2008, the Government of China released The State Overall Planning for Post-Wenchuan Earthquake Restoration and Reconstruction (State Planning Group of Post-Wenchuan Earthquake Restoration and Reconstruction, 2008) for implementation. The guarantee of people's well-being was deemed the fundamental issue in the post-Wenchuan Earthquake restoration and reconstruction plan. Accordingly, to comprehensively guide the process of recovery, the Chinese State Council took a critical step issuing the Post-Wenchuan Earthquake Recovery Master Plan (PWERM). The first principle of this plan envisaged a combination of self-reliance in the disaster-affected areas, national support, and paired assistance. Unlike many Western countries, China has a top-down administrative system. This implies that the Chinese central government has the ultimate policy-making power and it can direct subnational governments to a particularly high extent. In other words, the master plan served as the fundamental guideline for all actors involved.

To further elaborate, this master plan provided guidelines on the goals of reconstruction, including priorities for industrial reconstruction, and it defined the financial responsibilities of the major actors in the reconstruction process. The major goals under the plan were six folds: (1) Every family has a house or apartment to live in; (2) at least one member of each family should have a stable job and their annual disposable personal income should exceed the pre-disaster level; (3) everyone should enjoy basic social welfare, i.e., free 9-year public education, public health and basic medical care, social welfare, and other basic public services; (4) public facilities should be upgraded, and infrastructure in the areas of communication, transportation, energy, and irrigation should be fully restored; (5) the economy of the earthquake-stricken area should be further developed; and (6) the natural environment should be improved (State Council of the PRC, 2008; Zuo, 2008). The master plan encouraged different actors to be involved in the reconstruction process and identified the Paired Assistance Policy as the core mechanism for recovery.

5.2.2 Paired Assistance Policy

Paired assistance is a resource allocation mechanism that promotes fast development in one area or one policy domain by devoting resources from other areas or policy domains. It existed in China before the Wenchuan Earthquake and used in three manners: assisting the development of border areas and minority areas, supporting key infrastructure projects (such as the Three Gorges Dam), and supporting disaster response and reconstruction (Wang & Dong, 2010). The use of the counterpart assistance program in disaster reconstruction started in the 1950s and became salient in responding to the 1978 drought disaster in Hubei Province (Zhong, 2011) and 1991 Tai Lake flood (Duan et al., 2009).

After the 2008 Wenchuan Earthquake, the central government decided to mobilize the paired assistance program. The headquarter onsite, also called as the office for pairing assistance, was formed by members from the supporting and supported areas, with the assistance of the coordinator province department or commission. The headquarter administered the reconstruction and recovery work based on the discussion of both sides. The contents of the PAP system are shown in Figure 5.3.

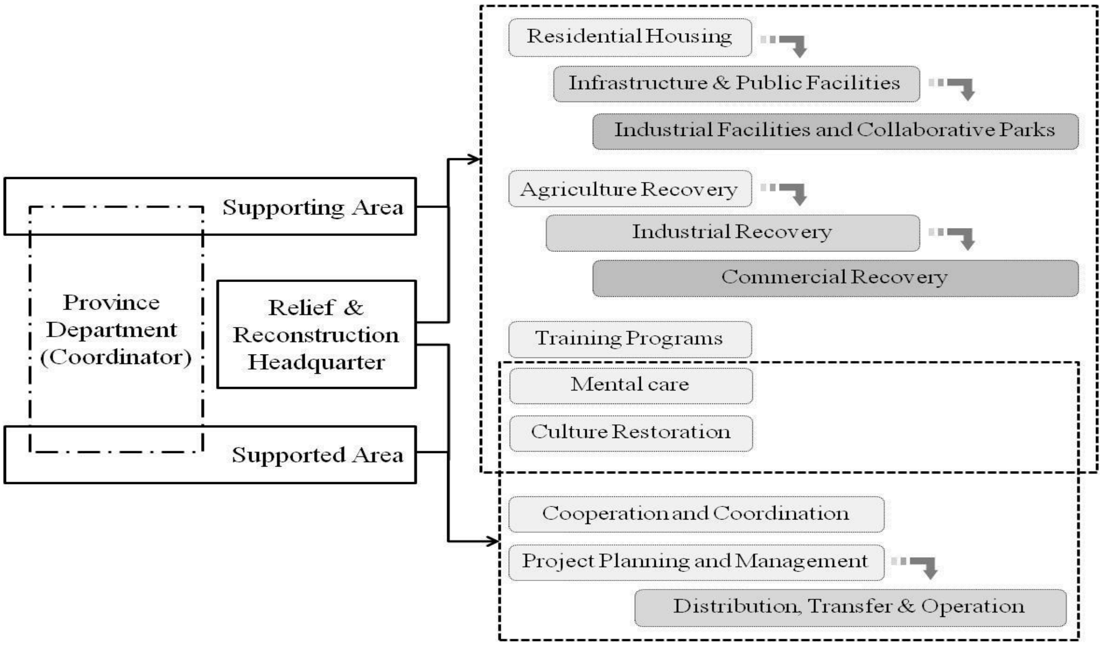


Figure 5.3 The contents of the PAP system
(Qian et al., 2013)

According to the *Master Plan and Post-Wenchuan Earthquake Recovery and Reconstruction Counterpart Assistance Program,* 20 economically developed provinces, unaffected by the earthquake, were assigned to assist 18 counties and severely afflicted areas in Gansu and Shaanxi Provinces. Table 5.1 shows the list of assisting parties and their assisted parties in disaster hit counties and also the funds of their total investments, aid funds and projects. For example, Shanghai was paired up with Dujiangyan County, and Guangdong province was paired up with Wenchuan County.

Table 5.10 Funds of total investment, aid fund and projects of the 20 pairs in PAP from 2008 to 2011

	Assisting party	Assisted party	Investment (RMB Billion)	Aid fund (RMB Billion)	Completed projects
1	Guangdong	Wenchuan County	8.7	1.3	702
2	Jiangsu	Mianzhu City	11.2	1.3	128
3	Shanghai	Dujiangyan City	8.25	1.1	117
4	Shandong	Beichuan County	12.1	2.4	369
5	Zhejiang	Qingchuan County	21.5	6	852
6	Beijing	Shifang City	7.0	——	108
7	Fujian	Penzhou City	3.7	——	146
8	Tianjin	Shaanxi Province	3.584	2.037	295
9	Liaoning	Anxian County		4.027	88
10	Anhui	Songpan County	2.13	——	320
11	Henan	Jiangyou City	3.0	——	300
12	Hebei	Pingwu County	2.8	——	108
13	Chongqing	Cangzhou City	——	1.7	111
14	Shenzhen	Gansu Province	4.5	——	165
15	Jilin	Heishui County	——	1.3	201
16	Hunan	Lixian County	2.010	——	99
17	Shanxi	Maoxian County	2.15	——	226
18	Hubei	Hanyuan County	——	2.0	116
19	Heilongjiang	Jiange County	——	1.55	146
20	Jiangxi	Xiaojin County	——	1.3	128

(Data resource: 3rd Anniversary topics of Wenchuan Earthquake, People's Daily Online.)

Supporting provinces and cities were required to provide support for reconstruction of supported areas in 3 years, allocating no less than 1% of local fiscal revenue of the former year for goods and work operations each year. The aids included reconstruction of residential housing; reconstruction of public facilities such as schools and hospitals; reconstruction of infrastructures such as water supply and treatment; reconstruction of agriculture and related infrastructure; machinery equipment, construction materials. Besides the hardware recovery, software recovery was also included, such as planning, professional consulting, training people, and education service. In summary, the relief work was implemented from all the aspects of material, fiscal resources, manpower and intelligence. For long-term tasks, the economic recovery, including agriculture, industries and commercial activities, was also expected to be realized by the support of investments from industries, such as collaborative industrial parks.

5.2.3 The reconstruction practice of Paired Assistance Policy

Even though the post-Wenchuan Earthquake reconstruction process faced a high number of challenges, it was completed within three years and generated positive social and economic outcomes in many regions. According to official statistics, by April 2011, 94.34% of the 41,130 national reconstruction projects invested in the affected areas for the post-disaster reconstruction were completed (Figure 5.4).

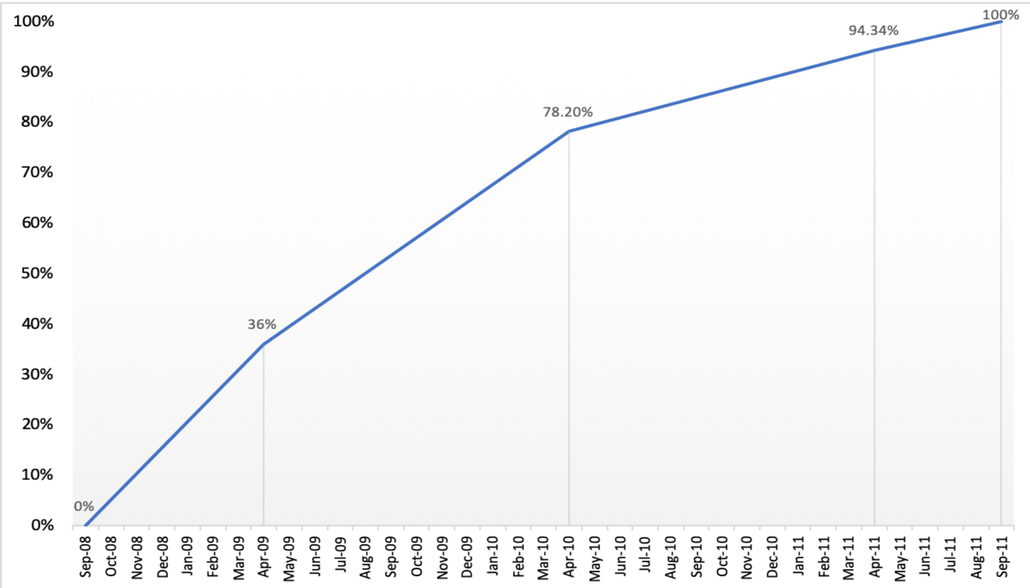


Figure 5.4 Reconstruction progress of Wenchuan Earthquake

The master plan encouraged different actors to be involved in the reconstruction process and identified the PAP as the core mechanism for recovery. By April 2011, a total of 885.3 billion yuan (US $ 126.3 billion) was invested in the post-disaster reconstruction of the Sichuan province. Sources of the reconstruction funds are reported in Table 5.1. From this table, it can be found that these investments were funded by multi-stakeholders, such as the central government, assisting parties, social donators. Figure 5.5 shows a pie chart with the percentage of the composition of various attracted funds. Additionally, 2,740 officials and 310,000 workers were sent to the affected areas from 18 aid-provision provinces, of which, 29,400 were teachers, doctors, policemen and other civil occupations (Xu & Lu, 2013).

Table 5.2 Sources of reconstruction funds in Sichuan province

Resource	RMB (Billion)
Central government	220.3
Assisting parties	78
Hongkong & Macao	13
Party membership dues	8
Social donation	21
Foreign preferential loans	8
Local government	40
Financial institutions Loans	390
Others (Local government bonds, social capital et al.)	107
Total	885.3

(Data resource: Four measures in Sichuan to solve the fund gap of 500 billion yuan in post disaster reconstruction, Chinanews.)

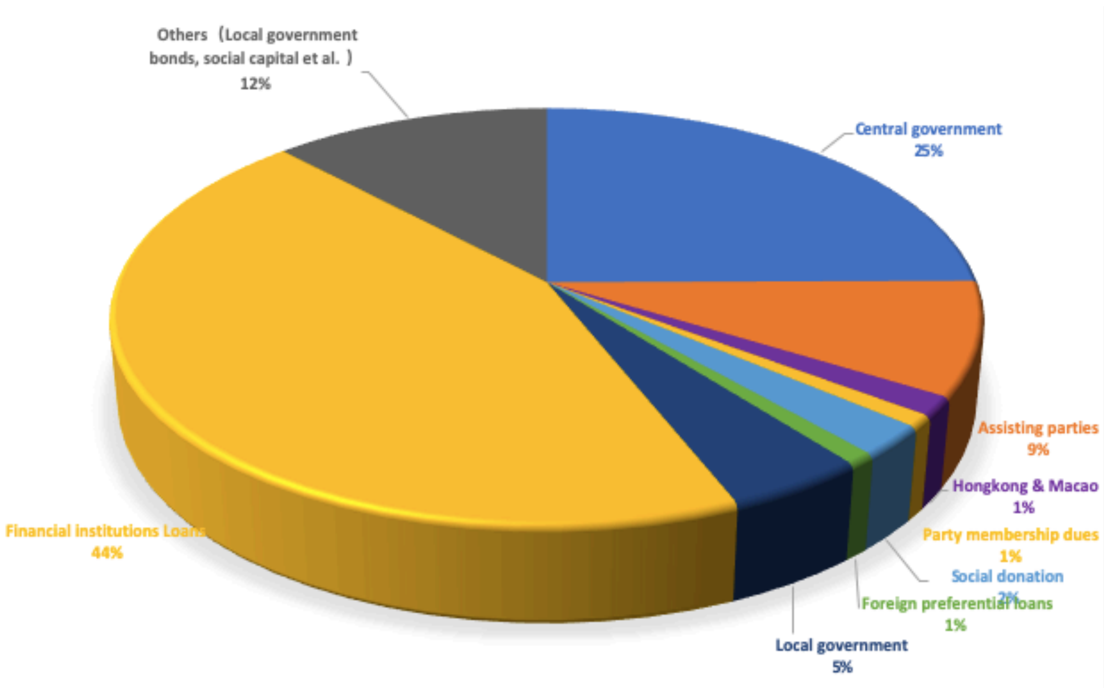


Figure 5.5 Composition of funds' resource

5.3 The SD model of the collaborative governance in post-Wenchuan Earthquake reconstruction

5.3.1 Modeling development

The post-disaster recovery of Wenchuan Earthquake was a dynamic, complex, and long-term process. Policies and strategies assumed a critical role to ensure the availability of resources required for long-term reconstruction efforts (Chang et al., 2010). The responsibility for designing and implementing reconstruction policies rests primarily with the government. In Wenchuan case, local governments play their main roles through the PAP program.

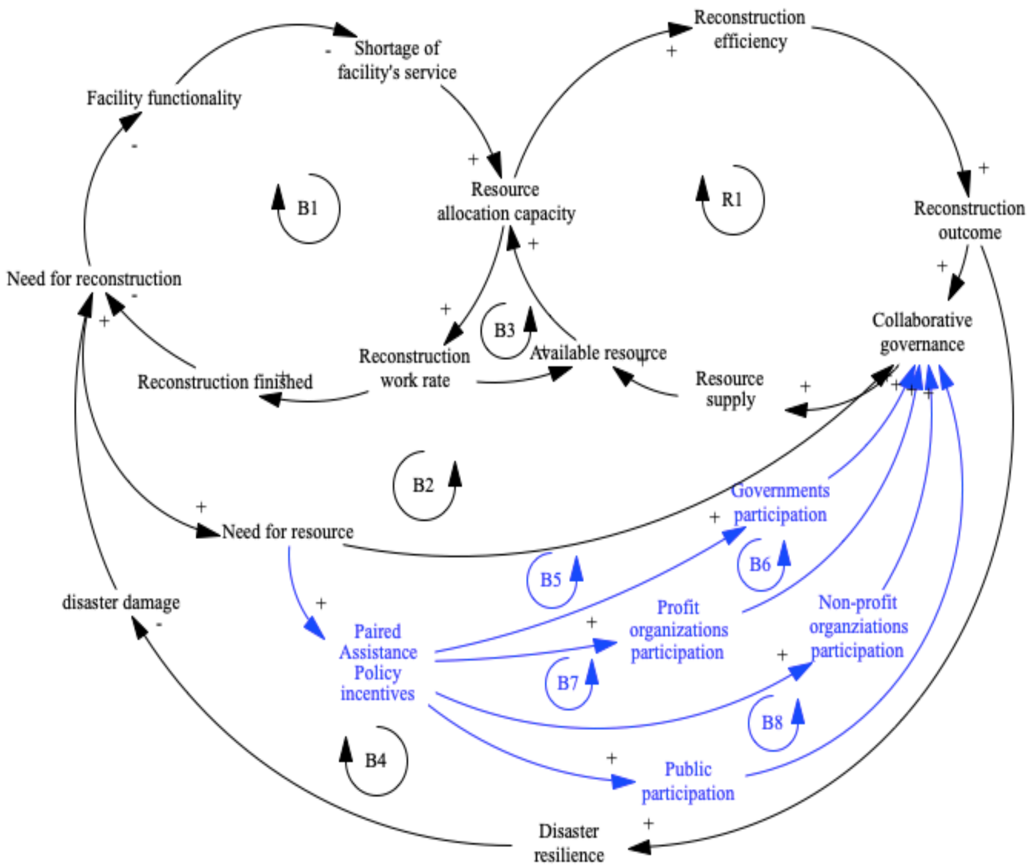


Figure 5.6 Post-disaster reconstruction and collaborative governance in Wenchuan Earthquake (Adapted from Hwang et al., 2014)

The affected areas in Wenchuan Earthquake suffered fatal losses in various aspects. Lots of reconstruction activities needed to be carried out urgently. The enormous demand for resources was impossible to be accomplished by a single actor. Therefore, collaborative governance among multiple stakeholders was necessary. PAP was used by the government as policy lever in the Wenchuan case to enhance collaborative governance among all stakeholders involved. Based on the analysis of Figure 4.2 and Table 4.1 the chapter four, the general causal loop diagrams of the post-disaster reconstruction and collaborative governance is developed in accordance with the Wenchuan Earthquake case (Figure 5.6). This session focuses on how the PAP affects collaborative governance in post-disaster reconstruction. In other words, it mainly discusses the effects of PAP on the relationships among multi-stakeholders, including the central and local governments, profit and non-profit organizations, and the public.

(1) PAP effect on participation of the governments

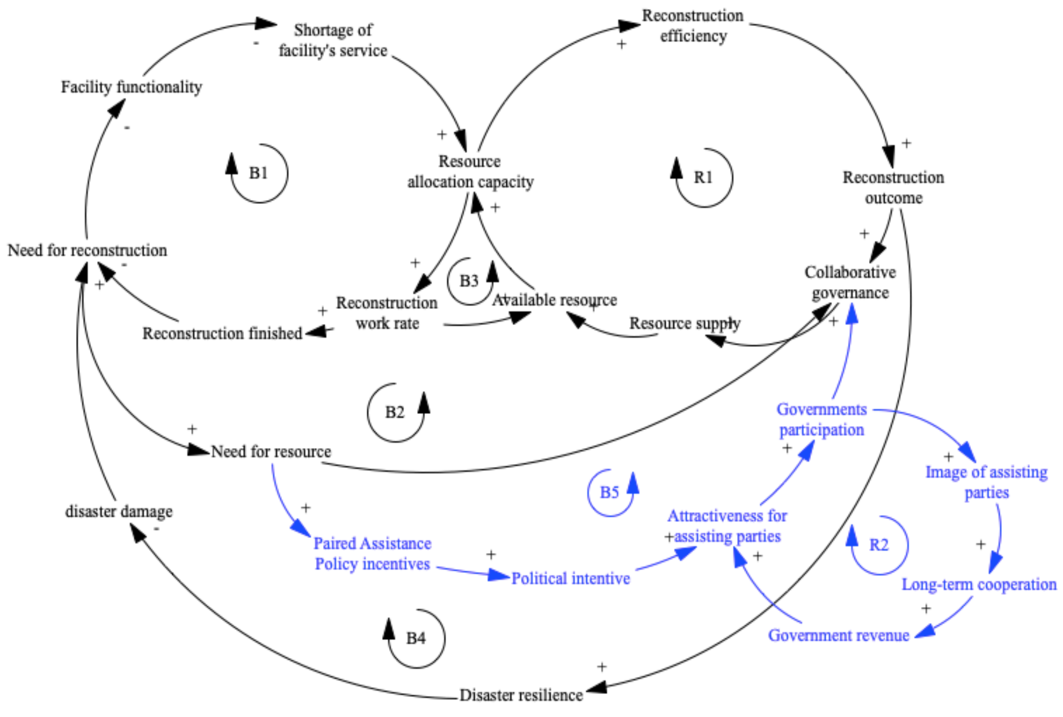


Figure 5.7 PAP effect on participation of the governments

In an early phase, the formation of collaborations was made possible by the political mobilization of the Chinese central government as well as the intergovernmental command-and control relationships among the local governments. However, by the end of the 3-year PAP period, the relationships between the governments in the collaborative governance changed. The assisting local governments were no longer operating primarily as agents of the central government, but were operating according to goals they set by themselves (Tang, 2019). In other words, as assisting local governments began pursuing their own designed aims, their recovery efforts evolved from paired assistance to counterpart cooperation. Therefore, the benefit reciprocity through post-disaster and reconstruction efforts also became another driving factor for the participation of assisting parties (Loop R2 in Figure 5.7). The mutual relationship generated through the PAP extended its long-term effect to deepen the cooperation in the fields of agriculture, industry, commerce and trade, tourism, and culture.

(2) Policy effect on participation of profit organizations

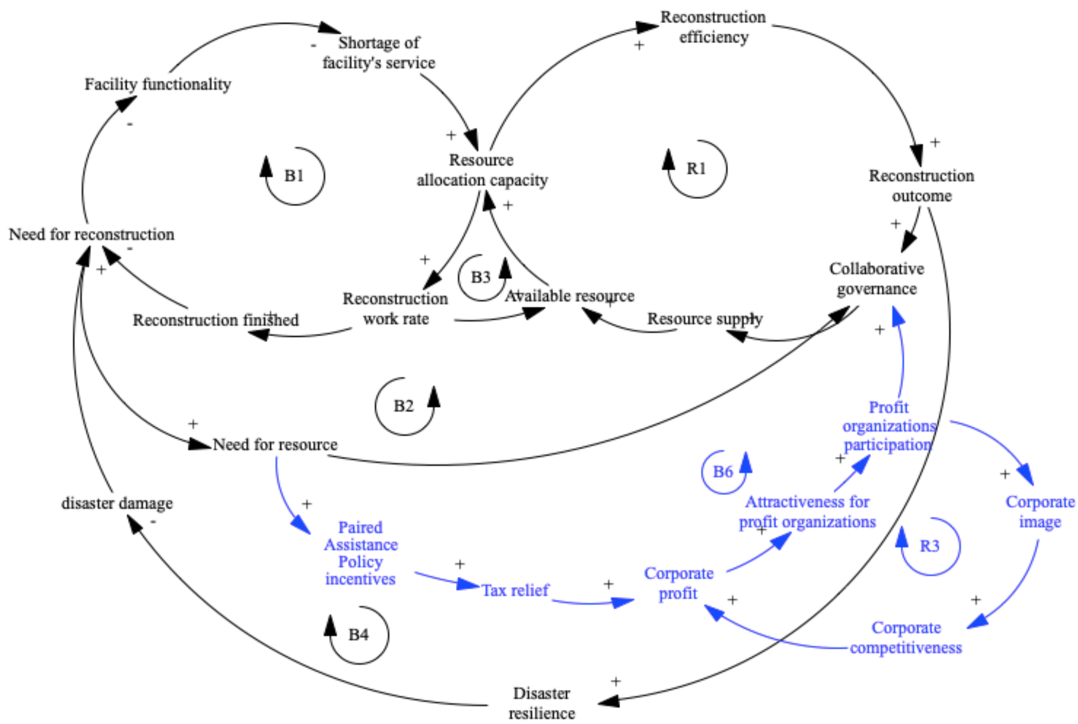


Figure 5.8 PAP effect on participation of profit organizations

The central government's PWERM clearly defined the principle of the recovery as a combination of "blood transfusion" and "blood making" to be pursued in accordance with a market-oriented operation. Therefore, this phenomenon encourages enterprises to invest in disaster-affected areas with the active involvement of social organizations During the 3-year PAP period, under the guidance of the assisting and assisted governments, the market played a substantive role in the collaborative governance among stakeholders. For example, in the Shanghai-Dujiangyan PAP, assisting and assisted parties collectively signed approximately 100 economic cooperation contracts totaling CNY5.76 billion related to industry, agriculture, science and technology, tourism, and business (Tang, 2019). Although government departments played guiding roles during this stage, market participation played the leading role. Meanwhile, profit organizations could also benefit from the participation of reconstruction in the aspect of fulfilling social responsibility, which could contribute to the improvement of corporate image. This could help profit organizations to increase their attractiveness/competitiveness and gain more profits (Loop R3 in Figure 5.8). Such an assumption is supported by the research conducted on the relationships between corporate social responsibility and corporate competitive advance by Kramer and Porter (Porter & Kramer, 2007).

(3) Policy effect on participation of non-profit organizations

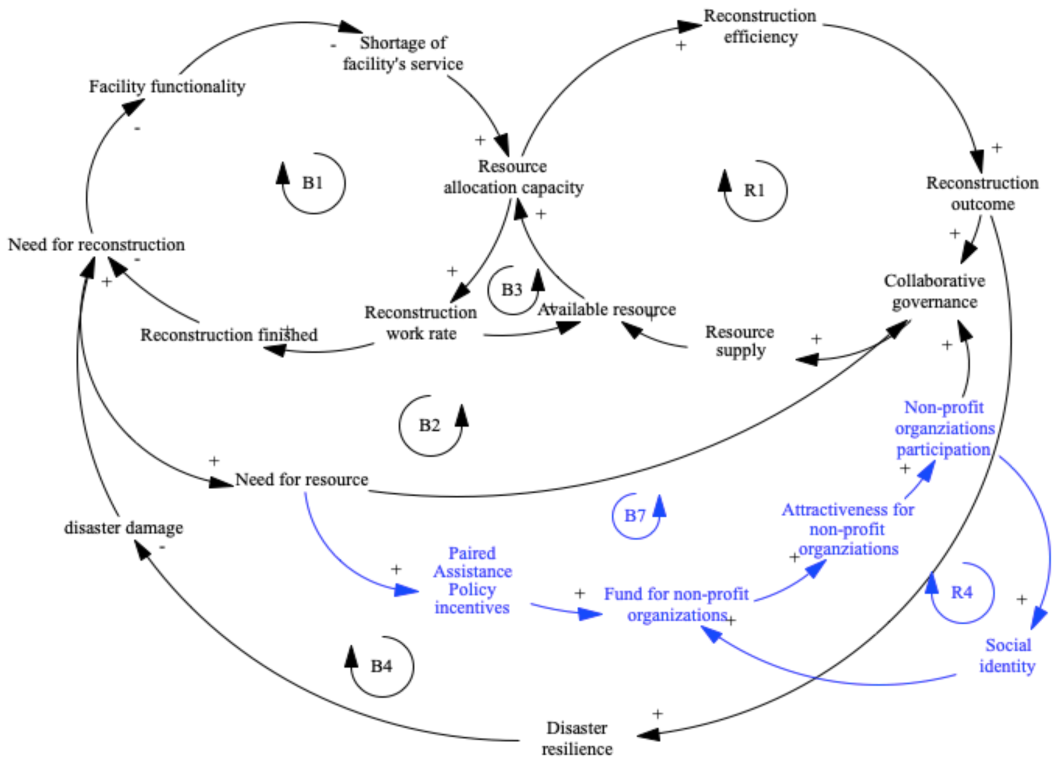


Figure 5.9 PAP effect on participation of non-profit organizations

The Paired Assistance Policy made a significant contribution to social participation. Other non-profit organizations such as schools and hospitals were also included in the PAP to provide various types of software and intelligence support. For example, in 2008 and 2009, 120 teachers from Shanghai were sent to Dujiangyan to help improve the level of education management and information technology. In medical technical support, Shanghai Jiaotong University, Fudan University, Shanghai University of Traditional Medicine, and the Shanghai Center for Disease Control and Prevention sent support teams to rural areas to carry out relief work and help restore public health services (Tang, 2019). Besides the funds support from Paired Assistance Policy, participating in post-disaster reconstruction also helped these non-profit organizations to improve their social identity. The raise in social identity fulfilled the process oriented to obtaining more funding in future development (Loop R4 in Figure 5.9).

(4) Policy effect on participation of the public

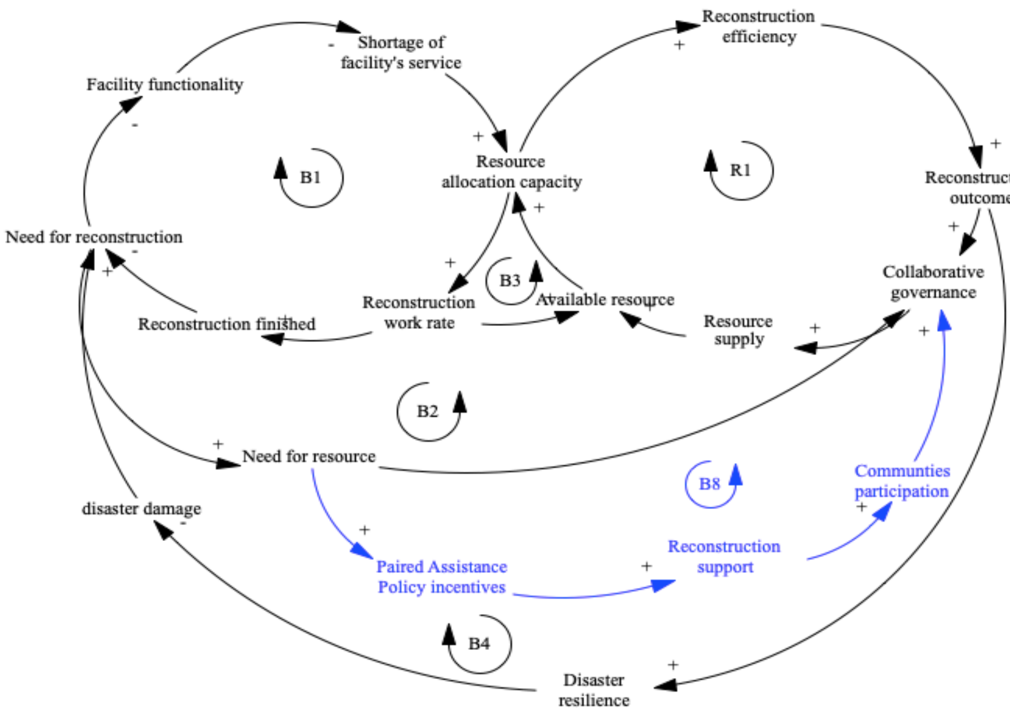


Figure 5.10 PAP effect on the participation of the public

The public also played an important role in the process of paired assistance. For example, communities in Pudong New District in Shanghai donated gifts valued at 900 thousand RMB to 5979 families in need in their counterpart communities and sent 54 social workers to provide support for families and elderly people. This reconstruction support increased the communities' participation in the collaborative governance (Loop B8 in Figure 5.9).

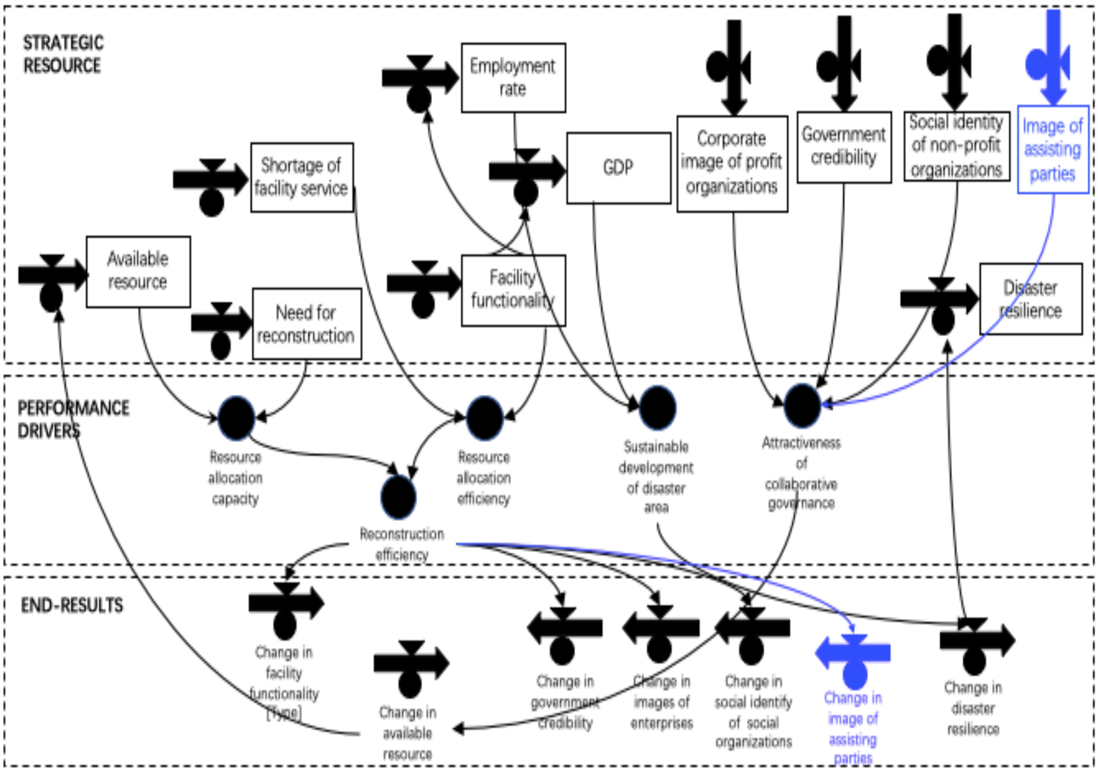


Figure 5.11 DPM chart portraying the relationship between collaborative governance and post-disaster reconstruction in Wenchuan earthquake

The causal loop diagrams reported from figures 5.5 to 5.10 offers the basic information to design and build a full DPM chart. Figure 5.11 illustrates a generic DPM framework of the collaborative governance in the post-disaster reconstruction modified from Figure 4.4. One end-result named "the change in image of assisting parties" and one strategic resource named "Image of assisting parties" are added (shown in blue). Besides the stakeholders (the government, profit organizations, non-profit organizations and the public) analyzed in the last chapter, assisting parties is the fifth participation sector that needs to be included in Wenchuan Earthquake. Image of assisting parties as an impartment objective of assisting parties, it affects assisting parties' interest to contributing to post-disaster reconstruction. Therefore, to boost the attractiveness of collaborative governance, it is needed to take the improvement of assisting parties' image into consideration.

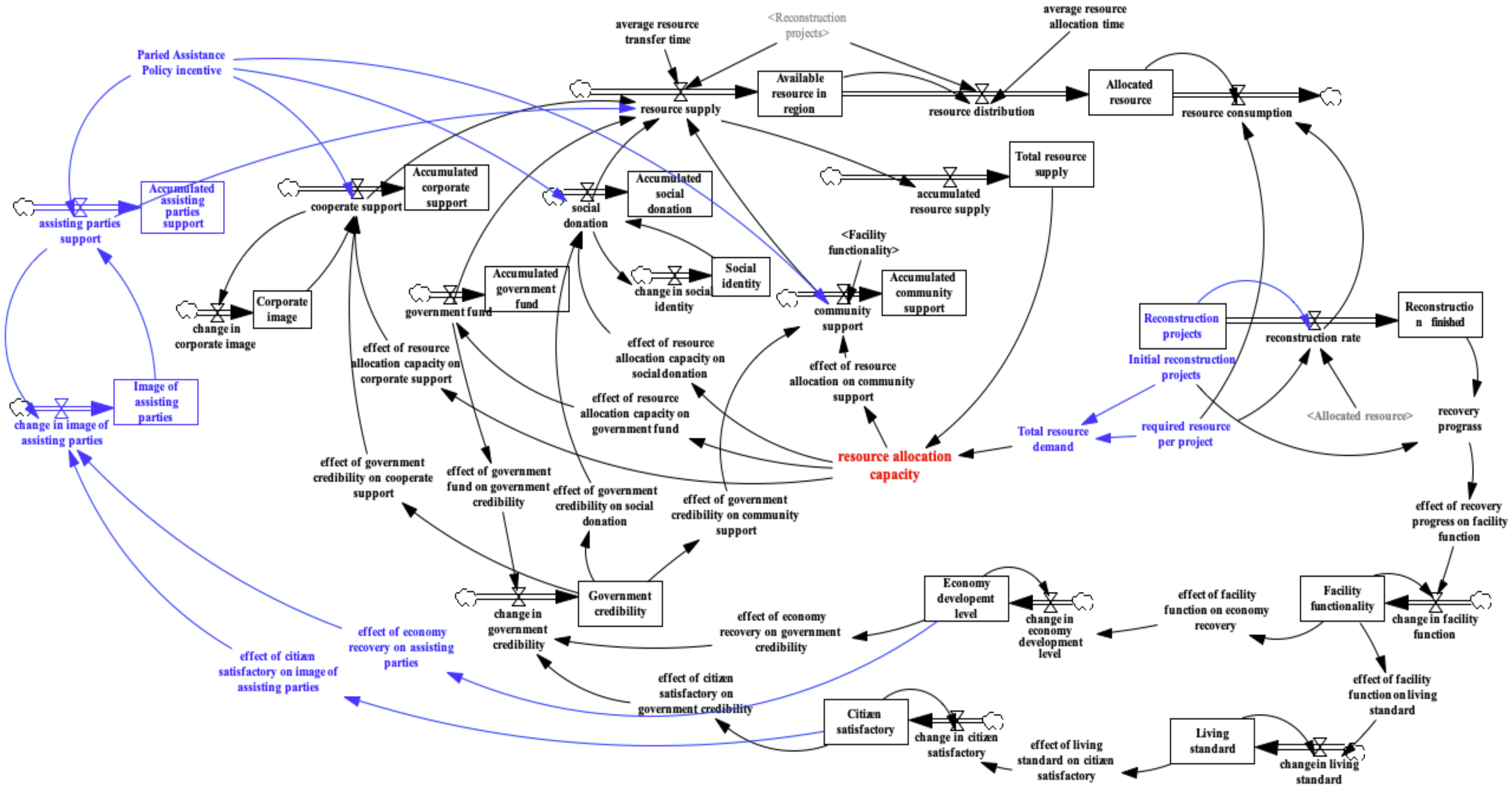


Figure 5.12 The stock and flow diagram model—the mechanism of resource supply affected by Paired Assistance Policy

By using the findings from the casual loop diagrams and the DPM diagram, the generic stock-and-flow diagram discussed in the previous chapter was customized based on the Wenchuan Earthquake case. A new mechanism of resource supply was added to illustrate the participation of assisting parties and the PAP's effect on other stakeholders. The model structure shows how, on the one hand, PAP incentives can support the assisting parties in the post-disaster reconstruction. On the other hand, it depicts how the PAP incentives positively impact on the resource supply from profit organizations, non-profit organizations and communities. Equations and parameters were entered for all variables.

Table 5.3 Initial values of the key model variables

Variable	Initial value	Remarks
Initial reconstruction projects	41,130 Projects	Total number of national reconstruction projects by April, 2011
Required resource per project	0.0215 Billion/Project	It is calculated by dividing the total investment 885.3 Billion by total number of national reconstruction projects
Average government fund	8.036 Billion/Month	It is calculated by dividing the total investment 289.3 Billion from central government, Hongkong & Macao, party membership dues and local government by total duration of reconstruction projects 36 months
Average corporate support	13.805 Billion/Month	It is calculated by dividing the total investment 390 Billion from financial institutions by total duration of reconstruction projects 36 months
Average assisting parties support	2.167 Billion/Month	It is calculated by dividing the total investment 78 Billion from assisting parties by total duration of reconstruction projects 36 months
Average community support	2.972 Billion/Month	It is calculated by dividing the total investment 107 Billion from others by total duration of reconstruction projects 36 months
Average social donation	0.583 Billion/Month	It is calculated by dividing the total investment 21 Billion from social donation by total duration of reconstruction projects 36 months

In order to execute the final SD model portrayed in Figure 5.12, it is necessary to add more auxiliary variables and input parameters. Simulation models also require to define initial values to variables, such as stocks, inputs and policy on which decision-makers can act on.

The initial values for the key variables and input parameters are reported in Tables 5.3 and 5.4.

Table 5.4 Sample input functions

Function
Reconstruction rate (Project/month) = IF THEN ELSE (Reconstruction project>0, MAX (Allocated resource/required resource per project,0), 0)
Total resource need (Billion) = Initial reconstruction projects*required resource per project
Resource supply (Resource/month) = IF THEN ELSE (Reconstruction project >0, (cooperate support + government fund + community support + social donation + assisting parties support)/resource transfer time,0)
Assisting parties support (Billion/month) = IF THEN ELSE(effect of Paired Assistance Policy on assisting parties support>0 , average assisting support*effect of Paired Assistance Policy on assisting parties support*effect of image of assisting parties on assisting parties support*effect of resource allocation capacity on assisting parties support , average assisting support*effect of image of assisting parties on assisting parties support*effect of resource allocation capacity on assisting parties support)
Resource allocation capacity = IF THEN ELSE (Total resource demand>0, Total resource supply/Total resource demand, 0)

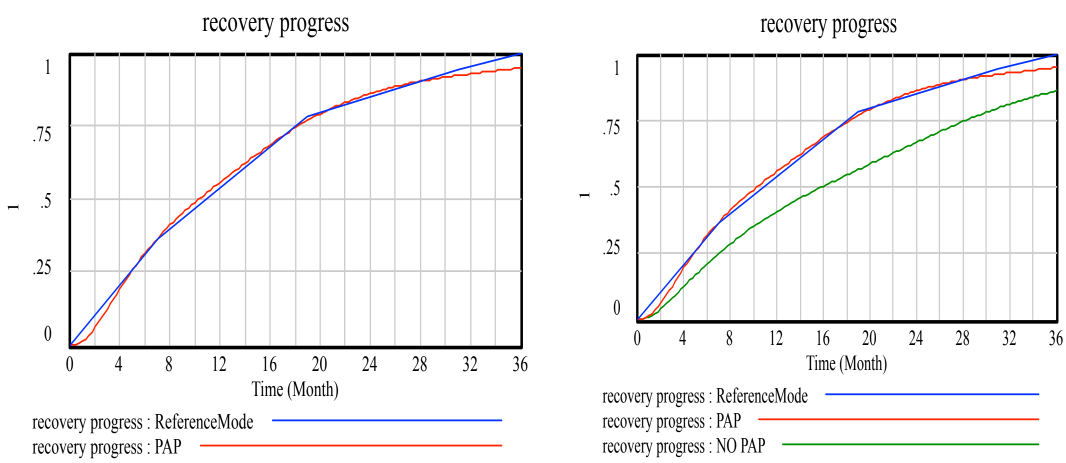
Six assumptions are embedded in this new model, such as:

- there's no secondary disasters；
- there's no difference in the categories of resource；
- the information in resource supply chain is symmetrical. This means the supply will not exceed demand；
- the resource supply is unlimited. This means all the stakeholders would constantly provide resources until post-disaster reconstruction is completed;
- the total numbers of reconstruction projects and investments are known at the start of reconstruction;
- the reconstruction operations would end in three years.

5.3.3 Model validation

In this chapter, validation tests have been carried out on both the "structure" and the "behavior" of the model. To verify the appropriateness of the model structure to capture all relevant variables impacting on the investigated phenomenon, at first, its boundaries have been modified to include all indigenous variables. Secondly, the test of extreme values was carried out to check for the logical connections among variables.

The model's behavior has been tested against the reference model of "Recovery progress". Figure 5.13a presents the simulation result of recovery progress in Wenchuan. In the post-Wenchuan Earthquake reconstruction, it shows that the recovery progress increases with a logarithmic growth curve instead of an S-shaped behavior. Table 5.12 shows the comparison of the simulation result of recovery progress and its reference mode (Figure 5.4). The comparison results show an acceptable difference between the results of simulation and filed data. In other word, the simulation model is able to replicate the actual situation. Figure 5.13b shown a comparison of the simulation results with and without PAP. This change provides evidence that the active participation of multiple stakeholders in the post-reconstruction process, based on the collaborative governance approach, overcomes the restriction of the relevant supporting infrastructures.



(a) (b)

Figure 5.13 Results of behavior test

Table 5.5 Comparison of the simulation result of recovery progress and reference mode

Recovery progress (months)	0	7	19	31	36
Simulation result	0	36.30%	76.68%	92.17%	94.79%
Actual data	0%	36%	78.20%	94.34%	100%

5.4 Model simulation and policy analysis

5.4.1 Model simulation

The model covers a simulation period of three years, while the time unit is expressed in months. Simulation results of the effects of collaborative governance in post-disaster reconstruction performance are depicted in Figure 5.14.

As one can observe, the trends of living standard, economic development level, corporate image, social identity, image of assisting parties and resource allocation capacity increase showing a logarithmic growth curve. These social-economic performance indicators grow faster in the early stage of the reconstruction.

The citizen satisfactory index, instead, shows an S-shaped growth curve. It slowly grows at the start of the post-disaster reconstruction. In the middle of the reconstruction, it raises to one. There is a time delay between the improvement of living standard and citizen satisfaction. This can partly be explained by that time is needed for recovering citizens' daily living, such as the education and health care. The simulation results of cooperate image of profit organizations and social identity of non-profit organizations implicitly show that the earlier the stakeholders take part in the collaborative governance in post-disaster reconstruction, the more they will get. If compared with other end-results, the raise in government credibility is relatively small. This is because the participation of paired assisting parties replaced, to a large extent, the role of the government. The decrease in government funds weakens the public perception of government credibility. However, government credibility experiences a trend of rapid growth in the later stage of reconstruction, once the PAP policy starts to generate beneficial outcomes in the reconstruction process. The model demonstrates how the PAP reconstruction mode will not damage the government credibility in the long run.

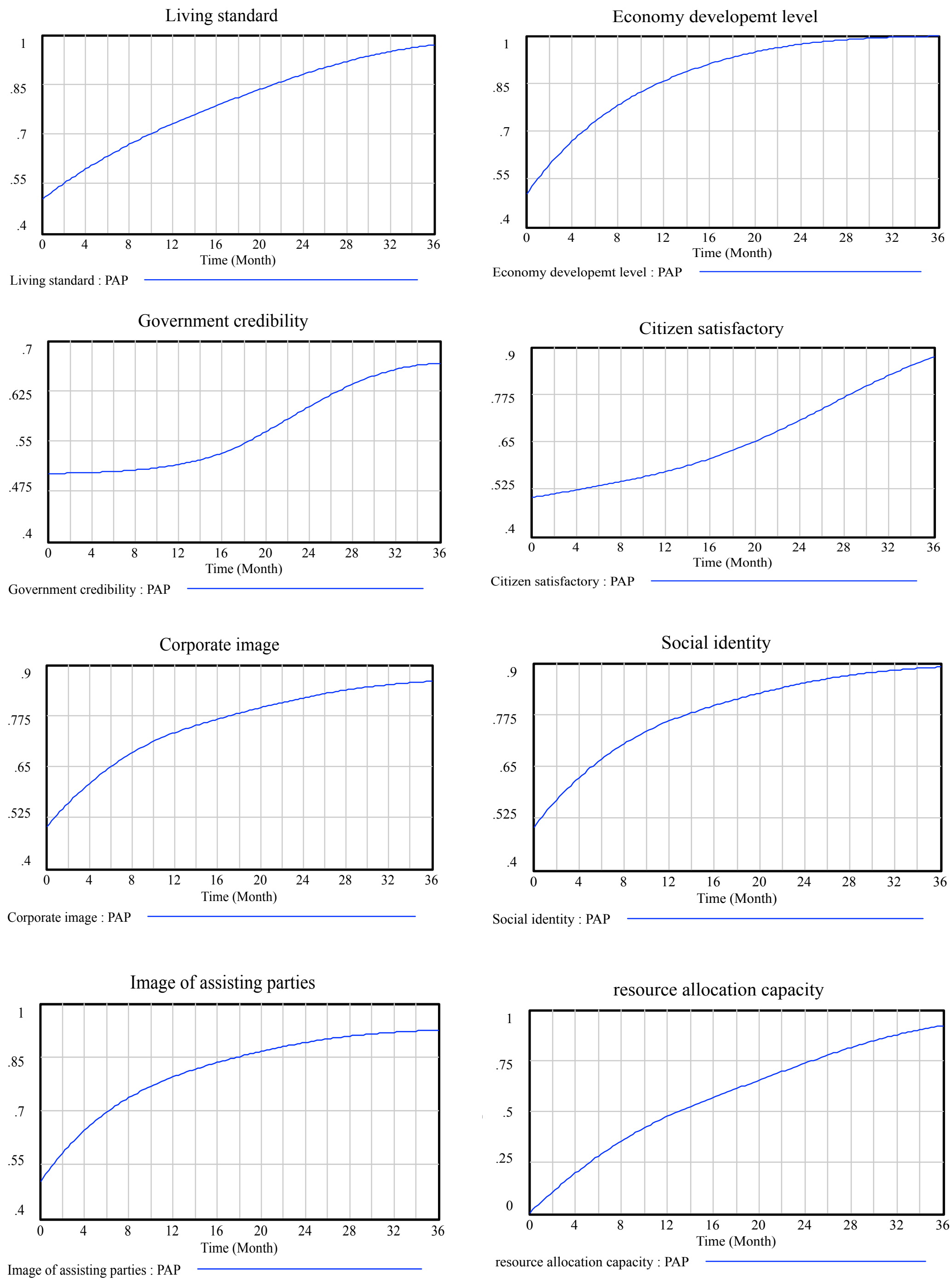


Figure 5.14 Simulation results of key variables in this PAP collaborative governance system

5.4.2 Policy analysis

This section shows the results of five alternative scenarios generated by the adoption of different decisions related to the policy interventions. Such policies are listed in Table 5.6.

Table 5.6 Policies set in the simulation model

Scenario No.	Policy lever	Initial value	Policy parameter
1	Average government fund	8.036 Billion/Month	12.054 Billion/Month
2	Government credibility	0.5	0.75
3	Average assisting parties support	2.167 Billion/Month	3.250 Billion/Month
4	Image of assisting parties	0.5	0.75
5	Facility functionality	0.2	0.4

Simulation results of key variables in this collaborative governance setting are shown in Figure 5.14.

The first scenario (PS1) assumes a direct control on resource supply in the post-disaster reconstruction, which implies a high government fund policy. As it can be observed from Figure 5.15, although this policy can improve resource allocation capacity, its effect on living standard, economic development level and citizen satisfactory is not obvious. Moreover, from a long-term perspective, it is not conducive setting to the improvement of government credibility. This is because government funds will reduce rapidly if the investments needed are too high, mainly, at the early stage of the post-disaster reconstruction. It means that the effects of such a control policy on government funds may contribute to reduce government credibility. In addition, it has a negative impact on the corporate image of profit organizations, the social identity of non-profit organizations and the image of assisting parties. This phenomenon can be explained as consequence of the excessive investments from government, which may suppress the participation of profit organizations, non-profit organizations and assisting parties. Therefore, a high government fund policy may not a good way post-disaster reconstruction governance

The second scenario (PS2) aims at increasing government credibility from 0.5 to 0.75through an improvement of government leadership in the post-disaster reconstruction. Comparing with other polices, the resource allocation capacity has the most explosive growth in this scenario. It is worth noting that the improvement of government credibility has a significant positive effect on the corporate image of profit organizations and the social identity of non-profit organizations. However, it has a

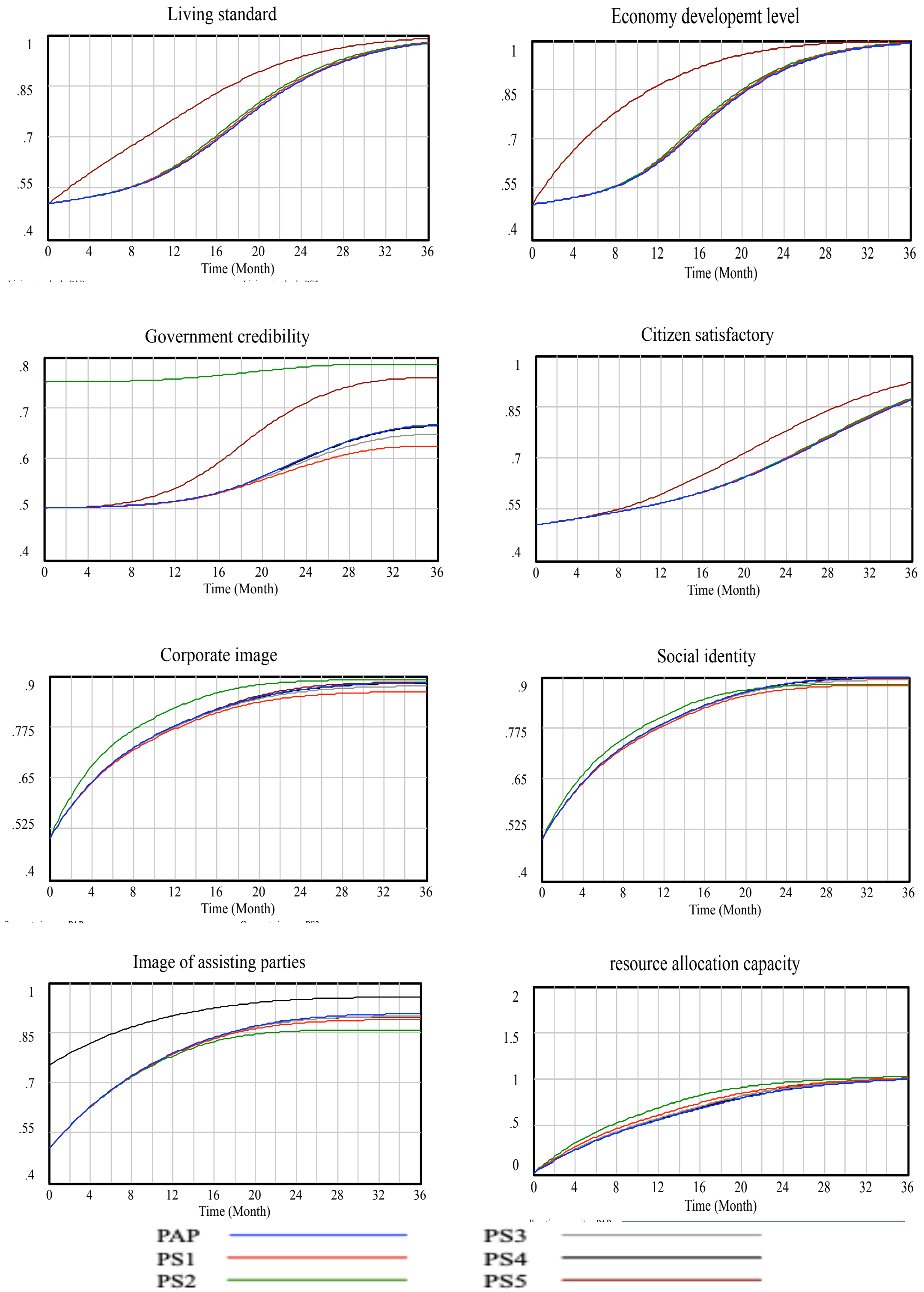


Figure 5.15 Simulation results of key variables in PAP collaborative governance system according to different policies

negative impact on the image of assisting parties. This can be explained as the government and the assisting parties are playing a similar role in the post-Wenchuan Earthquake reconstruction. The increment of the government credibility will limit the role of assisting parties. Therefore, it can be concluded that it is necessary to balance the role government and assisting parties in order to achieve an effective collaborative governance in the post-disaster reconstruction process

The third scenario (PS3) examines the effect of increasing assisting parties support on the collaborative governance among stakeholders. It assumes that the resource supplied by the assisting parties will raise 1.5 times compared the previous scenario. The simulation results do not show a significant change in these key performance indicators. The most significant change appears in the change of government credibility. It illustrates that excessive participation of assisting parties does not contribute to improve the government leadership.

The fourth scenario (PS4) assumes that the image of assisting parties will increase from 0.5 to 0.75. Similar simulation result was obtained with PS2. Therefore, this policy produces a very limited impact on the post-disaster reconstruction practice.

The fifth scenario (S5) aims to examine the effect of facility functionality on the post-disaster reconstruction. It assumes that the community has a higher resistance than before. The higher resistance protects the community to suffer a less disaster damage. These simulation results show that, even if there is not an improvement in resource allocation capacity and recovery progress, all variables, such as government credibility, living standard, economic development and citizen satisfaction experience a massive growth. This policy works better on the social and economic reconstruction.

5.5 Discussion and conclusions

Based on the post-Wenchuan Earthquake reconstruction, this chapter outlines the Sd model simulation results of the combined use of PAP reconstruction mode in post-disaster reconstruction. It provides a new perspective to better understand the effect of PAP in post-disaster reconstruction. The policy analysis conducted in this research can support decision makers in the effective implementation of reconstruction practices (e.g., reconstruction progress, economic recovery) and in the improvement of social-economic indicators (e.g., government credibility, citizen satisfaction).

The interactions of multi-stakeholders, especially the paired assisting parties, in post-Wenchuan Earthquake reconstruction were investigated and made explicit in a SD simulation model. The dynamic of resource supply, reconstruction, resource allocation, and collaborative governance among the government, paired assisting parties, profit and non-profit organizations, and the public were modeled. The validity of the SD model built was performed using structural and behavioral tests. Simulation results supports that the PAP reconstruction mode is an effective way to improve the resource allocation capacity and post-disaster reconstruction performance than the traditional way. Meanwhile, it reveals that balancing the role of government credibility and paired assisting parties is a critical problem in the post-Wenchuan Earthquake reconstruction.

Scenarios findings and lessons learned from policy analysis can be used to support specific guidelines for future post-disaster reconstruction practices. The PAP collaborative governance could also provide useful experience and lessons for many other countries.

However, the actual post-disaster reconstruction is much complex than expected. Even though this study offers new knowledge on the PAP effects on collaborative governance in post-reconstruction practices, further researches are needed to explore such a collaboration deeper. For example, social reconstruction and psychological reconstruction are ignored one this study

Therefore, further research is necessary to investigate other relevant aspects of the post-disaster reconstruction, which would enhance collaborative governance in the post-disaster reconstruction and to achieve a more sustainable community and society.

Chapter 6 Discussion and Conclusions

This chapter discusses the key finding and presents the contributions of the research, together with its limitations and suggestions for future research. It ends with the conclusions emanating from this research.

6.1 Discussion of key findings

Long-term outcomes and collaborative governance are particularly worthy of discussion when examining the reconstruction practice from natural disasters. In the long and dynamic processes of reconstruction, multiple stakeholders' participation is the best way to address issues such as insufficient capacity to solve problems and immediate demands for significant funding.

The aim of this doctoral thesis is to discuss how collaborative governance fosters efficiency and effectiveness in post-disaster reconstruction and recovery phases. Collaborations among multiple stakeholders, such as the governments, profit and non-profit organizations and the public, were examined through qualitative and quantitative method.

Unlike the traditional performance management systems, which measure post-disaster reconstruction by focusing on economic metric, such as schedule performance, cost performance and safety performance, this research investigates post-disaster reconstruction from an outcome-based approach. The DPM framework provided in Chapter 3 highlighted hat social-economic indicators such as living standard, citizen satisfaction, government credibility, corporate image and the image of non-profit organizations should be included within the scope of performance management of collaborative governance in the post-disaster reconstruction. These findings suggest that policy-makers need to consider the different objectives for each stakeholder (e.g., the improvement of government credibility, the improvement of enterprises' images, and the improvement of social organizations' social identify) when designing the post-reconstruction plan. This innovative dynamic performance management framework aims to provide a contribution in the evolutionary pattern of performance management models of post-disaster reconstructions.

The quantitative SD model discussed in Chapter 4 explained the effect of the social-economic indicators on collaborative governance in the post-disaster reconstruction. Simulation results show that excessive investments from government may suppress the participation of profit and non-profit organizations. Government credibility also demonstrated its critical role to ensure the successful implementation of a collaborative governance approach. The findings also support that effective collaborative governance is helpful to improve the post-disaster reconstruction performance. Meanwhile, it is proved that improving the communities' resistance works better on the social and economic reconstruction than other polices.

To further improve the general model, a customized SD model of the post-Wenchuan Earthquake reconstruction is discussed in Chapter 5. The updated model took the innovative Paired Assistance Policy into consideration. It modelled the impact of policy incentives on multiple stakeholders. Simulation results demonstrated that the PAP collaborative governance mode had a positive impact on the participation of multiple actors, which contributed to achieving an improvement of the performance, in terms of efficiency and effectiveness, in the post-disaster reconstruction and recovery. At the same time, it suggested to decision makers to pay attention to balance the role of central and local governments and paired assisting parities.

6.2 Summary of the research contribution

This study aims to provide a contribution to fill multiple current research gaps. defines collaborative governance in post-disaster reconstruction more clearly and contributes to the understanding of how collaborative governance can improve post-disaster reconstruction effectiveness. Chapter 3 represents a novel outcome-based Dynamic Performance Management approach to frame the performance outcomes of collaborative governance in post-disaster reconstruction. It offers a framework to support decision-makers in identifying key measures and to design effective policies to improve collaborative governance in post-disaster reconstruction activities. Chapter 4 uses the system dynamics methodology to analyse the dynamic features of a collaborative governance approach in post-disaster reconstruction. The dynamic of resource supply, reconstruction, resource allocation, and collaborative governance among the government, profit and non-profit organizations, and the public were modeled. Chapter 5 offers an illuminating case study for better understanding the dynamic collaborative governance in post-disaster reconstruction based on the post-Wenchuan Earthquake reconstruction. This research analyzes the special “Paired Assistance Policy” (PAP) collaborative governance mode of in post-Wenchuan Earthquake reconstruction and presents a SD model to identify the key factors impacting on the outcomes of the PAP collaborative governance mode.

The research as a whole helps to enhancing collaborative governance in pot-disaster reconstruction (e.g., through the perspective of anticipation of multiple stakeholders), challenges common beliefs (e.g., that the more government funding, the better post-disaster reconstruction), shows that policies and decision strategies are subject to dynamic and endogenous interaction that can enhance collaborative governance in pot-disaster reconstruction, prioritizes prior knowledge based on systemic interaction (e.g., government credibility, image of paired assisting parties and facility functionality matter as important leverage points), and expands existing methodologies (e.g., Dynamic Performance Management and System Dynamics modelling). Thus, besides the importance of discipline-specific knowledge, it advocates the complementary benefits of a system-based approach that incorporates the dynamic complexity of systems.

6.3 Limitations of the research and suggestions for future research

Despite the several contributions that this research offers, it is not without limitations.

Firstly, this study examined the collaborative governance in the post-disaster reconstruction from only limited theoretical perspective, which were new public management, collaborative governance and performance management. Other perspectives or theoretical approaches such as network theory, urban theory and decision-making theory could also be considered for a better understanding of collaborative governance in the post-disaster reconstruction.

Secondly, the DPM framework and SD model is developed based on the literature review and case studies. The exploration for the mental model of relative stakeholders is still inadequate. To overcome this limitation, group model building will be conducted to achieve more in-depth understanding of the topic.

Thirdly, this research relied on the second-hand data to simulate the SD models which limited its accuracy and relevance. Future researchers might consider doing study on first hand data. For example, the citizen satisfactory questionnaires survey can be designed to obtain first hand data.

Last but least, this research explores the post-disaster from an aggregate view. There is much more room for further research on collaborative governance in a specified area of the post-disaster reconstruction, such as the psychological reconstruction and social reconstruction.

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Appendix A List of the variables and functions of SD model in Chapter 4

(1) Accumulated community support= INTEG (community support,0)

Units: resource

This variable represents the total resource from communities during the reconstructing period.

(2) Accumulated cooperate support= INTEG (corporate support,0)

Units: resource

This variable represents the total resource from profit organizations during the reconstructing period.

(3) Accumulated government fund= INTEG (government fund,0)

Units: resource

This variable represents the total resource from governments during the reconstructing period.

(4) accumulated resource supply= resource supply

Units: resource/Month

This variable represents the total resource from governments, paired assisting parties, communities, profit organizations and non-profit organization each month.

(5) Accumulated social donation= INTEG (social donation,0)

Units: resource

This variable represents the total resource from non-profit organizations during the reconstructing period.

(6) Allocated resource= INTEG (resource distribution-resource consumption,0)

Units: resource

This variable represents the resource allocated to the post-disaster reconstruction that can be put into use immediately.

(7) Available resource in region= INTEG (resource supply-resource distribution,0)

Units: resource

This variable represents the resource that is available for the reconstruction in the disaster area.

(8) average community support=4000

Units: resource/Month

This constant represents the resource expected supplied by paired assisting parties each month.

(9) average cooperate support=5000

Units: resource/Month

This constant represents the resource expected supplied by communities each month.

(10) average government fund=7000

Units: resource/Month

This constant represents the resource expected supplied by governments each month.

(11) average project duration=6

Units: Month

This constant represents the average time needed to reconstruct each facility.

(12) average resource allocation time=1

Units: Month

This constant represents the time needed to allocate the available resource to the reconstruction project.

(13) average resource transfer time=1

Units: Month

This constant represents the time needed to transfer the resource from its supplier to the disaster area.

(14) average social donation=3000

Units: resource/Month

This constant represents the resource expected supplied by non-profit organizations each month.

(15) change in citizen satisfactory= (1-Citizen satisfactory) *effect of living standard on citizen satisfactory

Units: 1/Month

This variable represents the change in citizen satisfactory each month. The function shows that citizen satisfactory changes according to the living standard. When citizen satisfactory is small, it is very sensitive to living standard. The impact of living standard on citizen satisfactory will decrease as citizen satisfactory increases.

(16) change in cooperate image= (1-Corporate image) *effect of corporate support on cooperate image

Units: 1/Month

This variable represents the change in corporate image each month. The function shows that corporate image changes according to the corporate support. When corporate image is small, it is very sensitive to corporate support. The impact of corporate support on corporate image will decrease as corporate image increases.

(17) change in economy development level= (1-Economy development level) *effect of facility function on economy recovery

Units: 1/Month

This variable represents the change in economy development level each month. The function shows that economy development level changes according to the facility function. When economy development level is small, it is very sensitive to facility function. The impact of facility function on economy development level will decrease as economy development level increases.

(18) change in facility function= (1-Facility functionality) *effect of recovery progress on facility function

Units: 1/Month

This variable represents the change in facility function each month. The function shows that facility function changes according to the recovery progress. When facility function is small, it is very sensitive to recovery progress. The impact of recovery progress on facility function will decrease as facility function increases.

(19) change in government credibility= (1-Government credibility) *effect of citizen satisfactory on government credibility*effect of economy recovery on government credibility*effect of government fund on government credibility

Units: 1/Month

This variable represents the change in government credibility each month. The function shows that government credibility changes according to the citizen satisfactory, economy recovery and government fund. When government credibility is small, it is very sensitive to the citizen satisfactory, economy recovery and government fund. The impact of the citizen satisfactory, economy recovery and government fund will decrease as government credibility increases.

(20) change in living standard= (1-Living standard) *effect of facility function on living standard

Units: 1/Month

This variable represents the change in living standard each month. The function shows that image of living standard changes according to the facility function. When living standard is small, it is very sensitive to facility function. The impact of facility function on living standard will decrease as living standard increases.

(21) change in social identity= (1-Social identity) *effect of social donation on society identify

Units: 1/Month

This variable represents the change in social identity each month. The function shows that social identity changes according to the social donation. When social identity is small, it is very sensitive to social donation. The impact of social donation on social identity will decrease as social identity increases.

(22) Citizen satisfactory= INTEG (change in citizen satisfactory,0.5)

Units: Dmnl

This stock represents the citizen satisfactory of the public in the disaster area. Its value is 0.5 at the start.

(23) community support=average community support*Facility functionality*effect of government credibility on community support

Units: resource/Month

This variable represents actual resource supplied by communities each month. In the real practice, the resource supplied by communities is not constant. It is affected by many factors, such as the facility functionality, resource allocation capacity and government credibility.

(24) Corporate image= INTEG (change in cooperate image,0.5)

Units: Dmnl

This stock represents the image of profit organizations perceived by the public in the disaster area. Its value is 0.5 at the start.

(25) corporate support=average cooperate support*effect of resource allocation capacity on cooperate support*effect of government credibility on cooperate support*effect of corporate image on corporate support

Units: resource/Month

This variable represents actual resource supplied by profit organizations each month. In the real practice, the resource supplied by profit organizations is not constant. It is affected by many factors, such as the corporate image, resource allocation capacity and government credibility.

(26) corporate support ratio=corporate support/average cooperate support

Units: 1

This variable represents the difference between actual resource supplied by profit organizations and the resource expected supplied by profit organizations.

(27) damage generation=SMOOTH3(disaster damage*event occurrence, time to identify disaster damage)

Units: facilities/Month

This variable represents the new reconstruction new generated by the disaster each month.

(28) disaster damage=50000

Units: facilities

This variable represents the damaged generated by the disaster.

(29) Economy development level= INTEG (change in economy development level,0.5)

Units: Dmnl

This stock represents the image of economy development level in the disaster area. Its value is 0.5 at the start.

(30) effect of citizen satisfactory on government credibility = WITH LOOKUP (DELAY1(Citizen satisfactory, 3), ([(0.5,0) -(1,1)], (0.5,0.01), (0.75,0.25), (1,0.5)))

Units: Dmnl

This variable represents the impact of citizen satisfactory on government credibility. The function shows citizen satisfactory has a positive impact government credibility.

(31) effect of corporate image on corporate support = WITH LOOKUP (Corporate image, ([(0.5,0) -(1,10)],(0.5,1),(0.75,1.2),(1,1.5)))

Units: Dmnl

This variable represents the impact of corporate image on corporate support. The function shows corporate image has a positive impact on corporate support. The reason is the improvement of corporate image will increase the corporate competitiveness, which will contribute to the growth in corporate revenue. Then corporates could supply more resource to the post-disaster reconstruction.

(32) effect of corporate support on cooperate image = WITH LOOKUP (corporate support ratio, ([(0,0) -(6,3)], (0,0),(1,0.05),(3,0.1),(6,0.15)))

Units: Dmnl

This variable represents the impact of corporate support on corporate image. The function shows corporate support has a positive impact on corporate image.

(33) effect of economy recovery on government credibility = WITH LOOKUP (DELAY1(Economy development level, 3), ([(0.5,0) -(1,1)], (0.5,0.05), (0.75,0.25), (1,0.5)))

Units: Dmnl

This variable represents the impact of economy recovery on government credibility. The function shows economy recovery has a positive impact on government credibility.

(34) effect of facility function on economy recovery = WITH LOOKUP (SMOOTH3(Facility functionality, 6), ([(0.2,0) -(1,1)], (0.2,0), (0.5,0.1), (0.75,0.15), (1,0.2)))

Units: Dmnl

This variable represents the impact of facility function on economy recovery. The function shows facility function has a positive impact on economy recovery.

(35) effect of facility function on living standard = WITH LOOKUP (DELAY1(Facility functionality ,3), ([(0.2,0) -(1,1)], (0.2,0.01), (0.5,0.05), (0.75,0.1), (1,0.15)))

Units: Dmnl

This variable represents the impact of facility function on living standard. The function shows facility function has a positive impact on living standard.

(36) effect of government credibility on community support = WITH LOOKUP (Government credibility, ([(0,0)- (2,2)],(0,0.5),(0.5,0.75),(1,1),(1.5,1.25),(2,1.5)))

Units: Dmnl

This variable represents the impact of government credibility on community support. The function shows government credibility has a positive impact on community support. A higher government credibility can strengthen the communities' trust on government and encourage them to support the post-disaster reconstruction more actively.

(37) effect of government credibility on cooperate support = WITH LOOKUP (DELAY1(Government credibility, 1), ([(0,0)- (1,10)], (0,0.2), (0.25,0.4), (0.5,0.6), (0.75,1), (1,1.25)))

Units: Dmnl

This variable represents the impact of government credibility on the resource supply from profit organizations. The function shows government credibility has a positive impact on cooperate support. A higher government credibility can strengthen the corporates' trust on government and encourage them to support the post-disaster reconstruction more actively.

(38) effect of government credibility on social donation = WITH LOOKUP (DELAY1(Government credibility, 1), ([(0,0)- (1,2)], (0,0.2),(0.5,0.75),(1,1.2)))

Units: Dmnl

This variable represents the impact of government credibility on social donation. The function shows government credibility has a positive impact on social donation. A higher government credibility can strengthen the ono-profit organizations' trust on government and encourage them to support the post-disaster reconstruction more actively.

(39) effect of government fund on government credibility = WITH LOOKUP (government fund ratio, ([(0,0) -(2,1)], (0,0),(1,0.3),(2,0.6)))

Units: Dmnl

This variable represents the impact of government fund on government credibility. The function shows government fund has a positive impact on government credibility.

(40) effect of living standard on citizen satisfactory = WITH LOOKUP (DELAY (Living standard, 3), ([(0.5,0) -(1,1)], (0.5,0.01),(0.75,0.05),(1,0.1)))

Units: Dmnl

This variable represents the impact of living standard on citizen satisfactory. The function shows living standard has a positive impact on citizen satisfactory. With the increase of living standard, the public will perceive a higher satisfactory for the reconstruction practice.

(41) effect of recovery progress on facility function = WITH LOOKUP (SMOOTH3(recovery progress, 6), ([(0,0) -(1,0.5)], (0,0.01), (0.25,0.1), (0.5,0.2), (0.75,0.22), (1,0.25)))

Units: Dmnl

This variable represents the impact of recovery progress on facility function. The function shows recovery progress has a positive impact on the facility function.

(42) effect of resource allocation capacity on cooperate support = WITH LOOKUP (resource allocation capacity, ([(0,0)-(1,10)],(0,2),(0.25,1.5),(0.5,1),(0.75,0.5),(1,0)))

Units: Dmnl

This variable represents the impact of resource allocation capacity on cooperate support. The function shows resource allocation capacity has a negative impact on the resource from cooperates. The reason is when there's a huge gap between resource supply and demand, cooperates' support will provide more resource to fulfil this gap. While, the resource supply from cooperates will reduce when resource supply close to resource demand.

(43) effect of resource allocation capacity on government fund = WITH LOOKUP (resource allocation capacity, ([(0,0) -(1,10)],(0,2),(0.25,1.5),(0.5,1),(0.75,0.5),(1,0)))

Units: Dmnl

This variable represents the impact of resource allocation capacity on government fund. The function shows resource allocation capacity has a negative impact on the resource from governments. The reason is when there's a huge gap between resource supply and demand, governments' support will provide more resource to fulfil this gap. While, the resource supply from governments will reduce when resource supply close to resource demand.

(44) effect of resource allocation capacity on social donation = WITH LOOKUP (resource allocation capacity, ([(0,0) -(1,10)],(0,2),(0.25,1.5),(0.5,1),(0.75,0.5),(1,0)))

Units: Dmnl

This variable represents the impact of resource allocation capacity on social donation. The function shows resource allocation capacity has a negative impact on the resource from non-profit organizations. The reason is when there's a huge gap between resource supply and demand, non-profit organizations' support will provide more resource to fulfil this gap. While, the resource supply from non-profit organizations will reduce when resource supply close to resource demand.

(45) effect of social donation on society identify = WITH LOOKUP (social donation ratio, ([(0, -2) -(6,3)],(0,0),(1,0.05),(3,0.1),(6,0.15)))

Units: Dmnl

This variable represents the impact of social donation on society identify. The function shows social donation has a positive impact on society identify.

(46) effect of social identify on social donation = WITH LOOKUP (Social identity, ([(0.5,0) -(1,10)],(0.5,1),(0.75,1.2),(1,1.5)))

Units: Dmnl

This variable represents the impact of social identify on social donation. The function shows corporate image has a positive impact on corporate support. The reason is the improvement of social identify will increase the non-profit organization's competitiveness, which will contribute to the growth in non-profit organization. Then non-profit organization could supply more resource to the post-disaster reconstruction.

(47) event occurrence=PULSE (1, 1)

Units: 1

This variable represents the occurrence of disaster. The function shows the disaster happens at time 1 and last 1-time unit.

(48) Facility functionality= INTEG (change in facility function,0.2)

Units: Dmnl

This stock represents the service capacity of the infrastructures in the disaster area. Its value is 0.2 at the start.

(49) FINAL TIME = 70

Units: Month

The final time for the simulation.

(50) Government credibility= INTEG (change in government credibility,0.5)

Units: Dmnl

This stock represents the government credibility perceived by the public in the disaster area. Its value is 0.5 at the start.

(51) government fund=average government fund*effect of resource allocation capacity on government fund

Units: resource/Month

This variable represents actual resource supplied by governments each month. In the real practice, the resource supplied by paired assisting parties is not constant. It is affected by resource allocation capacity.

(52) government fund ratio=government fund/average government fund

Units: 1

This variable represents the difference between actual resource supplied by governments and the resource expected supplied by governments.

(53) INITIAL TIME = 0

Units: Month

The initial time for the simulation.

(54) Living standard= INTEG (change in living standard,0.5)

Units: Dmnl

This stock represents the Image of assisting parties perceived by the public in the disaster area. Its value is 0.5 at the start.

(55) Need for reconstruction= INTEG (damage generation-reconstruction rate,0)

Units: facilities

This variable represents the damage needed to be reconstructed over time.

(56) Reconstruction finished= INTEG (reconstruction rate,0)

Units: facilities

This variable represents the total reconstruction projects reconstructed over time.

(57) reconstruction rate=IF THEN ELSE (Need for reconstruction>0, Allocated resource/required resource per facility/average project duration ,0)

Units: facilities/Month

This variable represents the working rate in the construction.

(58) recovery progress=Reconstruction finished/disaster damage

Units: 1

This variable represents the difference between reconstruction finished and the total reconstruction projects.

(59) required resource per facility=20

Units: resource/facilities

This variable represents the resource is needed for each facility.

(60) resource allocation capacity=IF THEN ELSE (Total resource demand>0, Total resource supply/Total resource demand, 0)

Units: 1

This variable represents the ratio of the total available resource over the total resource demand (Eq. 1). This index indicates that the more resources are supplied, the higher the resource allocation capacity is. On the other hand, the more resources are demanded, the lower resource allocation capacity will result.

(61) resource consumption=IF THEN ELSE (Allocated resource>=0, MAX(reconstruction rate*required resource per facility , 0) ,0)

Units: resource/Month

This variable represents the resource is consumed each month.

(62) resource demand=damage generation*required resource per facility

Units: resource/Month

This variable represents the resource is distributed to reconstruction each month.

(63) resource distribution=IF THEN ELSE (Need for reconstruction>0, MAX (Available resource in region/(average resource allocation time*Facility functionality),0) , 0)

Units: resource/Month

This variable represents the resource is distributed to reconstruction each month.

(64) resource supply=IF THEN ELSE (Need for reconstruction>0, (corporate support + government fund + community support + social donation)/average resource transfer time,0)

Units: resource/Month

This variable represents the total resource supplied by governments, profit and non-profit organizations, paired assisting parties and the public each month.

(65) SAVEPER = TIME STEP

Units: Month

The frequency with which output is stored.

(66) social donation=average social donation*effect of social identify on social donation*effect of resource allocation capacity on social donation*effect of government credibility on social donation

Units: resource/Month

This variable represents actual resource supplied by non-profit organizations each month. In the real practice, the resource supplied by non-profit organizations is not constant. It is affected by many factors, such as the image of assisting parties, resource allocation capacity, government credibility and its social identity.

(67) social donation ratio=social donation/average social donation

Units: 1

This variable represents the difference between actual resource supplied by non-profit organizations and the resource expected supplied by non-profit organizations.

(68) Social identity= INTEG (change in social identity,0.5)

Units: Dmnl

This stock represents the citizen satisfactory of the public in the disaster area. Its value is 0.5 at the start.

(69) TIME STEP = 0.25

Units: Month

The time step for the simulation.

(70) time to identify disaster damage=2

Units: Month

This variable represents to identify the damage needed to be reconstructed.

(71) Total resource demand= INTEG (resource demand,0)

Units: resource

This stock represents the total number of resource needed by the post-disaster reconstruction. It is determined by the number of reconstruction projects and the resource needed by each project.

(72) Total resource supply= INTEG (accumulated resource supply,0)

Units: resource

This stock represents the total number of resource supplied to the post-disaster reconstruction.

Appendix B List of the variables and functions of SD model in Chapter 5

(1) Accumulated assisting parties support= INTEG (assisting parties support,0)

Units: Billion

This variable represents the total resource from paired assisting parties during the reconstructing period.

(2) Accumulated community support= INTEG (community support,0)

Units: Billion

This variable represents the total resource from communities during the reconstructing period.

(3) Accumulated cooperate support= INTEG (corporate support,0)

Units: Billion

This variable represents the total resource from profit organizations during the reconstructing period.

(4) Accumulated government fund= INTEG (government fund,0)

Units: Billion

This variable represents the total resource from governments during the reconstructing period.

(5) accumulated resource supply=resource supply

Units: Billion/Month

This variable represents the total resource from governments, paired assisting parties, communities, profit organizations and non-profit organization each month.

(6) Accumulated social donation= INTEG (social donation,0)

Units: Billion

This variable represents the total resource from non-profit organizations during the reconstructing period.

(7) Allocated resource= INTEG (resource distribution-resource consumption,0)

Units: Billion

This variable represents the resource allocated to the post-disaster reconstruction that can be put into use immediately.

(8) assisting parties support=IF THEN ELSE (effect of Paired Assistance Policy on assisting parties support>0, average assisting support*effect of Paired Assistance Policy on assisting parties support*effect of image of assisting parties on assisting parties support*effect of resource allocation capacity on assisting parties support, average assisting support*effect of image of assisting parties on assisting parties support*effect of resource allocation capacity on assisting parties support)

Units: Billion/Month

This variable represents actual resource supplied by paired assisting parties each month. In the real practice, the resource supplied by paired assisting parties is not constant. It is affected by many factors, such as the Paired Assistance Policy, image of assisting parties, resource allocation capacity.

(9) assisting parties support ratio=assisting parties support/average assisting support

Units: 1

This variable represents the difference between actual resource supplied by paired assisting parties and the resource expected supplied by paired assisting parties.

(10) Available resource in region= INTEG (resource supply-resource distribution,0)

Units: Billion

This variable represents the resource that is available for the reconstruction in the disaster area.

(11) average assisting support=2.167

Units: Billion/Month

This constant represents the resource expected supplied by paired assisting parties each month. It is calculated by dividing the total investment 78 Billion from assisting parties by total duration of reconstruction projects 36 months.

(12) average community support=2.972

Units: Billion/Month

This constant represents the resource expected supplied by communities each month. It is calculated by dividing the total investment 107 Billion from others by total duration of reconstruction projects 36 months.

(13) average cooperate support=13.805

Units: Billion/Month

This constant represents the resource expected supplied by profit organizations each month. It is calculated by dividing the total investment 390 Billion from financial institutions by total duration of reconstruction projects 36 months.

(14) average government fund=8.036

Units: Billion/Month

This constant represents the resource expected supplied by governments each month. It is calculated by dividing the total investment 289.3 Billion from central government, Hongkong & Macao, party membership dues and local government by total duration of reconstruction projects 36 months.

(15) average resource allocation time=1

Units: Month

This constant represents the time needed to allocate the available resource to the reconstruction project.

(16) average resource transfer time=1

Units: Month

This constant represents the time needed to transfer the resource from its supplier to the disaster area.

(17) average social donation=0.583

Units: Billion/Month

This constant represents the resource expected supplied by non-profit organizations each month. It is calculated by dividing the total investment 21 Billion from social donation by total duration of reconstruction projects 36 months

(18) change in citizen satisfactory= (1-Citizen satisfactory) *effect of living standard on citizen satisfactory

Units: 1/Month

This variable represents the change in citizen satisfactory each month. The function shows that citizen satisfactory changes according to the living standard. When citizen satisfactory is small, it is very sensitive to living standard. The impact of living standard on citizen satisfactory will decrease as citizen satisfactory increases.

(19) change in cooperate image= (1-Corporate image) *effect of corporate support on cooperate image

Units: 1/Month

This variable represents the change in corporate image each month. The function shows that corporate image changes according to the corporate support. When corporate image is small, it is very sensitive to corporate support. The impact of corporate support on corporate image will decrease as corporate image increases.

(20) change in economy development level= (1-Economy development level) *effect of facility function on economy recovery

Units: 1/Month

This variable represents the change in economy development level each month. The function shows that economy development level changes according to the facility function. When economy development level is small, it is very sensitive to facility function. The impact of facility function on economy development level will decrease as economy development level increases.

(21) change in facility function= (1-Facility functionality) *effect of recovery progress on facility function

Units: 1/Month

This variable represents the change in facility function each month. The function shows that facility function changes according to the recovery progress. When facility function is small, it is very sensitive to recovery progress. The impact of recovery progress on facility function will decrease as facility function increases.

(22) change in government credibility= (1-Government credibility) *effect of citizen satisfactory on government credibility*effect of economy recovery on government credibility*effect of government fund on government credibility

Units: 1/Month

This variable represents the change in government credibility each month. The function shows that government credibility changes according to the citizen satisfactory, economy recovery and government fund. When government credibility is small, it is very sensitive to the citizen satisfactory, economy recovery and government fund. The impact of the citizen satisfactory, economy recovery and government fund will decrease as government credibility increases.

(23) change in image of assisting parties= (1-Image of assisting parties) *effect of assisting parties support on image of assisting parties

Units: 1/Month

This variable represents the change in image of paired assisting parties each month. The function shows that image of paired assisting parties changes according to the assisting parties support. When image of paired assisting parties is small, it is very sensitive to assisting parties support. The impact of assisting parties support on image of paired assisting parties will decrease as image of paired assisting parties increases.

(24) change in living standard= (1-Living standard) *effect of facility function on living standard

Units: 1/Month

This variable represents the change in living standard each month. The function shows that image of living standard changes according to the facility function. When living standard is small, it is very sensitive to facility function. The impact of facility function on living standard will decrease as living standard increases.

(25) change in social identity= (1-Social identity) *effect of social donation on society identify

Units: 1/Month

This variable represents the change in social identity each month. The function shows that social identity changes according to the social donation. When social identity is small, it is very sensitive to social donation. The impact of social donation on social identity will decrease as social identity increases.

(26) Citizen satisfactory= INTEG (change in citizen satisfactory, 0.5)

Units: Dmnl

This stock represents the citizen satisfactory of the public in the disaster area. Its value is 0.5 at the start.

(27) community support=IF THEN ELSE (effect of Paired Assistance Policy on community support>0, average community support*Facility functionality*effect of government credibility on community support*effect of Paired Assistance Policy on community support, average community support*effect of government credibility on community support*Facility functionality)

Units: Billion/Month

This variable represents actual resource supplied by communities each month. In the real practice, the resource supplied by communities is not constant. It is affected by many factors, such as the Paired Assistance Policy, facility functionality, resource allocation capacity and government credibility.

(28) Corporate image= INTEG (change in cooperate image,0.5)

Units: Dmnl

This stock represents the image of profit organizations perceived by the public in the disaster area. Its value is 0.5 at the start.

(29) corporate support=IF THEN ELSE(effect of Paired Assistance Policy on corporate support>0 , average cooperate support*effect of resource allocation capacity on cooperate support*effect of government credibility on cooperate support*effect of corporate image on corporate support*effect of Paired Assistance Policy on corporate support ,average cooperate support*effect of corporate image on corporate support*effect of government credibility on cooperate support*effect of resource allocation capacity on cooperate support)

Units: Billion/Month

This variable represents actual resource supplied by profit organizations each month. In the real practice, the resource supplied by profit organizations is not constant. It is affected by many factors, such as the Paired Assistance Policy, corporate image, resource allocation capacity and government credibility.

(30) corporate support ratio=corporate support/average cooperate support

Units: 1

This variable represents the difference between actual resource supplied by profit organizations and the resource expected supplied by profit organizations.

(31) Economy development level= INTEG (change in economy development level, 0.5)

Units: Dmnl

This stock represents the image of economy development level in the disaster area. Its value is 0.5 at the start.

(32) effect of citizen satisfactory on government credibility = WITH LOOKUP (DELAY1(Citizen satisfactory, 3), ([(0.5,0) -(1,1)], (0.5,0.01), (0.75,0.25), (1,0.5)))

Units: Dmnl

This variable represents the impact of citizen satisfactory on government credibility. The function shows citizen satisfactory has a positive impact government credibility.

(33) effect of corporate image on corporate support = WITH LOOKUP (Corporate image, ([(0.5,0) -(1,10)], (0.5,1),(0.75,1.2),(1,1.5)))

Units: Dmnl

This variable represents the impact of corporate image on corporate support. The function shows corporate image has a positive impact on corporate support. The reason is the improvement of corporate image will increase the corporate competitiveness, which will contribute to the growth in corporate revenue. Then corporates could supply more resource to the post-disaster reconstruction.

(34) effect of corporate support on cooperate image = WITH LOOKUP (corporate support ratio, ([(0,0) -(6,3)],(0,0),(1,0.05),(3,0.1),(6,0.15)))

Units: Dmnl

This variable represents the impact of corporate support on corporate image. The function shows corporate support has a positive impact on corporate image.

(35) effect of corporate support on image of assisting parties = WITH LOOKUP (assisting parties support ratio, ([(0,0)-(6,3)],(0,0),(1,0.05),(3,0.1),(6,0.15)))

Units: Dmnl

This variable represents the impact of assisting parties support on image of assisting parties. The function shows assisting parties support has a positive impact on image of assisting parties.

(36) effect of economy recovery on government credibility = WITH LOOKUP (DELAY1(Economy development level, 3), ([(0.5,0) -(1,1)], (0.5,0.05),(0.75,0.25),(1,0.5)))

Units: Dmnl

This variable represents the impact of economy recovery on government credibility. The function shows economy recovery has a positive impact on government credibility.

(37) effect of facility function on economy recovery = WITH LOOKUP (DELAY1 (Facility functionality, 3, ([(0.2,0) -(1,1)],(0.2,0.01),(0.5,0.1),(0.75,0.15),(1,0.2)))

Units: Dmnl

This variable represents the impact of facility function on economy recovery. The function shows facility function has a positive impact on economy recovery.

(38) effect of facility function on living standard = WITH LOOKUP (DELAY1(Facility functionality ,3), ([(0.2,0) -(1,1)],(0.2,0.01),(0.5,0.05),(0.75,0.1),(1,0.15)))

Units: Dmnl

This variable represents the impact of facility function on living standard. The function shows facility function has a positive impact on living standard.

(39) effect of government credibility on community support = WITH LOOKUP (Government credibility, ([(0,0) -(2,2)], (0,0.5),(0.5,0.75),(1,1),(1.5,1.25),(2,1.5)))

Units: Dmnl

This variable represents the impact of government credibility on community support. The function shows government credibility has a positive impact on community support. A higher government credibility can strengthen the communities' trust on government and encourage them to support the post-disaster reconstruction more actively.

(40) effect of government credibility on cooperate support = WITH LOOKUP (DELAY1(Government credibility, 1), ([(0,0) -(1,10)], (0,0.2), (0.25,0.4), (0.5,0.6), (0.75,1), (1,1.25)))

Units: Dmnl

This variable represents the impact of government credibility on the resource supply from profit organizations. The function shows government credibility has a positive impact on cooperate support. A higher government credibility can strengthen the corporates' trust on government and encourage them to support the post-disaster reconstruction more actively.

(41) effect of government credibility on social donation = WITH LOOKUP DELAY1(Government credibility, 1), ([(0,0) -(1,2)],(0,0.2),(0.5,0.75),(1,1.2)))

Units: Dmnl

This variable represents the impact of government credibility on social donation. The function shows government credibility has a positive impact on social donation. A higher government credibility can strengthen the ono-profit organizations' trust on government and encourage them to support the post-disaster reconstruction more actively.

(42) effect of government fund on government credibility = WITH LOOKUP (government fund ratio, ([(0,0) -(2.5,2)], (0,0), (1,0.75), (2,1),(2.5,1.5)))

Units: Dmnl

This variable represents the impact of government fund on government credibility. The function shows government fund has a positive impact on government credibility.

(43) effect of image of assisting parties on assisting parties support = WITH LOOKUP (Image of assisting parties, ([(0.5,0) -(1,10)], (0.5,1),(0.75,1.2),(1,1.5)))

Units: Dmnl

This variable represents the impact of image of assisting parties on assisting parties support. The function shows image of assisting parties has a positive impact on assisting parties support. The reason is the improvement of assisting parties' images will increase the trust between paired assisting parties and assisted parties. It is helpful to conduct long-term cooperation between these two parties, which will contribute to the growth in assisting parties' revenue. Then assisting parties could supply more resource to the post-disaster reconstruction.

(44) effect of living standard on citizen satisfactory = WITH LOOKUP (DELAY(Living standard, 3), ([(0.5,0) -(1,1)], (0.5,0.01),(0.75,0.05),(1,0.1)))

Units: Dmnl

This variable represents the impact of living standard on citizen satisfactory. The function shows living standard has a positive impact on citizen satisfactory. With the increase of living standard, the public will perceive a higher satisfactory for the reconstruction practice.

(45) effect of Paired Assistance Policy on assisting parties support=IF THEN ELSE (Paired Assistance Policy incentive=1, Paired Assistance Policy incentive*2 ,0)

Units: Dmnl

This variable represents the impact of Paired Assistance Policy on assisting parties support. When there's policy incentives, the assisting parties will increase their investment up to 2 times.

(46) effect of Paired Assistance Policy on social donation=IF THEN ELSE (Paired Assistance Policy incentive =1, 2*Paired Assistance Policy incentive, 0)

Units: Dmnl

This variable represents the impact of Paired Assistance Policy on social donation. When there's policy incentives, the non-profit organizations will increase their investment up to 2 times.

(47) effect of Paired Assistance Policy on corporate support=IF THEN ELSE (Paired Assistance Policy incentive =1, Paired Assistance Policy incentive*1.5, 0)

Units: Dmnl

This variable represents the impact of Paired Assistance Policy on corporate support. When there's policy incentives, the profit organizations will increase their investment up to 1.5 times.

(48) effect of Paired Assistance Policy on community support=IF THEN ELSE (Paired Assistance Policy incentive =1, Paired Assistance Policy incentive*1.5, 0)

Units: Dmnl

This variable represents the impact of Paired Assistance Policy on community support. When there's policy incentives, the non-profit organizations will increase their investment up to 1.5 times.

(49) effect of recovery progress on facility function = WITH LOOKUP (SMOOTH3(recovery progress, 6), ([(0,0) -(1,0.5)], (0,0.01), (0.25,0.1), (0.5,0.2), (0.75,0.3), (1,0.4)))

Units: 1

Units: Dmnl

This variable represents the impact of recovery progress on facility function. The function shows recovery progress has a positive impact on the facility function.

(50) effect of resource allocation capacity on assisting parties support = WITH LOOKUP (resource allocation capacity, ([(0,0) -(1,10)], (0,2.5), (0.25,1.75), (0.5,0.9), (0.75,0.7), (1,0)))

Units: Dmnl

This variable represents the impact of resource allocation capacity on assisting parties support. The function shows resource allocation capacity has a negative impact on the resource from assisting parties. The reason is when there's a huge gap between resource supply and demand, assisting parties support will provide more resource to fulfil this gap. While, the resource supply from assisting parties will reduce when resource supply close to resource demand.

(51) effect of resource allocation capacity on cooperate support = WITH LOOKUP (resource allocation capacity, ([(0,0) -(1,10)], (0,2.5), (0.25,1.75), (0.5,0.9), (0.75,0.7), (1,0)))

Units: Dmnl

This variable represents the impact of resource allocation capacity on cooperate support. The function shows resource allocation capacity has a negative impact on the resource from cooperates. The reason is when there's a huge gap between resource supply and demand, cooperates' support will provide more resource to fulfil this gap. While, the resource supply from cooperates will reduce when resource supply close to resource demand.

(52) effect of resource allocation capacity on government fund = WITH LOOKUP (resource allocation capacity, ([(0,0) -(1,10)], (0,2.5), (0.25,1.75), (0.5,0.9), (0.75,0.7), (1,0)))

Units: Dmnl

This variable represents the impact of resource allocation capacity on government fund. The function shows resource allocation capacity has a negative impact on the resource from governments. The reason is when there's a huge gap between resource supply and demand, governments' support will provide more resource to fulfil this gap. While, the resource supply from governments will reduce when resource supply close to resource demand.

(53) effect of resource allocation capacity on social donation = WITH LOOKUP (resource allocation capacity, ([(0,0) -(1,10)], (0,2.5), (0.25,1.75), (0.5,0.9), (0.75,0.7), (1,0)))

Units: Dmnl

This variable represents the impact of resource allocation capacity on social donation. The function shows resource allocation capacity has a negative impact on the resource from non-profit organizations. The reason is when there's a huge gap between resource supply and demand, non-profit organizations' support will provide more resource to fulfil this gap. While, the resource supply from non-profit organizations will reduce when resource supply close to resource demand.

(54) effect of social donation on society identify = WITH LOOKUP (social donation ratio, ([(0, -2) -(6,3)],(0,0),(1,0.05),(3,0.1),(6,0.15)))

Units: Dmnl

This variable represents the impact of social donation on society identify. The function shows social donation has a positive impact on society identify.

(55) effect of social identify on social donation = WITH LOOKUP (Social identity, ([(0.5,0) -(1,10)],(0.5,1),(0.75,1.2),(1,1.5)))

Units: Dmnl

This variable represents the impact of social identify on social donation. The function shows corporate image has a positive impact on corporate support. The reason is the improvement of social identify will increase the non-profit organization's competitiveness, which will contribute to the growth in non-profit organization. Then non-profit organization could supply more resource to the post-disaster reconstruction.

(56) Facility functionality= INTEG (change in facility function,0.2)

Units: Dmnl

This stock represents the service capacity of the infrastructures in the disaster area. Its value is 0.2 at the start.

(57) FINAL TIME = 36

Units: Month

The final time for the simulation.

(58) Government credibility= INTEG (change in government credibility,0.5)

Units: Dmnl

This stock represents the government credibility perceived by the public in the disaster area. Its value is 0.5 at the start.

(59) government fund=average government fund*effect of resource allocation capacity on government fund

Units: Billion/Month

This variable represents actual resource supplied by governments each month. In the real practice, the resource supplied by paired assisting parties is not constant. It is affected by resource allocation capacity.

(60) government fund ratio=government fund/average government fund

Units: 1

This variable represents the difference between actual resource supplied by governments and the resource expected supplied by governments.

(61) Image of assisting parties= INTEG (change in image of assisting parties,0.5)

Units: Dmnl

This stock represents the Image of assisting parties perceived by the public in the disaster area. Its value is 0.5 at the start.

(62) Initial reconstruction projects=41130

Units: project

This variable represents the total reconstruction projects needs to be reconstructed. It is the total number of national reconstruction projects by April, 2011.

(63) INITIAL TIME = 0

Units: Month

The initial time for the simulation.

(64) Living standard= INTEG (change in living standard,0.5)

Units: Dmnl

This stock represents the Image of assisting parties perceived by the public in the disaster area. Its value is 0.5 at the start.

(65) Paired Assistance Policy incentive=1

Units: Dmnl

This variable represents the implementation of Paired Assistance Policy.

(66) Reconstruction finished= INTEG (reconstruction rate,0)

Units: project

This variable represents the total reconstruction projects reconstructed over time.

(67) Reconstruction project= INTEG (-reconstruction rate, Initial reconstruction projects)

Units: project

This variable represents the total reconstruction projects needs to be reconstructed over time.

(68) reconstruction rate=IF THEN ELSE (Reconstruction project>0, Allocated resource/required resource per project ,0)

Units: project/Month

This variable represents the working rate in the construction.

(69) recovery progress=Reconstruction finished/Initial reconstruction projects

Units: 1

This variable represents the difference between reconstruction finished and the total reconstruction projects.

(70) required resource per project=0.02152

Units: Billion/project

This variable represents the resource is needed for each project. It is calculated by dividing the total investment 885.3 Billion by total number of national reconstruction projects.

(71) resource allocation capacity=IF THEN ELSE (Total resource demand>0, Total resource supply/Total resource demand , 0)

Units: 1

This variable represents the ratio of the total available resource over the total resource demand (Eq. 1). This index indicates that the more resources are supplied, the higher the resource allocation capacity is. On the other hand, the more resources are demanded, the lower resource allocation capacity will result.

(72) resource consumption=IF THEN ELSE (Allocated resource>=0, MAX (reconstruction rate*required resource per project, 0) ,0)

Units: Billion/Month

This variable represents the resource is consumed each month.

(73) resource distribution=IF THEN ELSE (Reconstruction project>0, MAX (Available resource in region/ (average resource allocation time*Facility functionality),0), 0)

Units: Billion/Month

This variable represents the resource is distributed to reconstruction each month.

(74) resource supply=IF THEN ELSE (Reconstruction project>0, (corporate support+ government fund+ community support+ social donation+ assisting parties support)/average resource transfer time,0)

Units: Billion/Month

This variable represents the total resource supplied by governments, profit and non-profit organizations, paired assisting parties and the public each month.

(75) SAVEPER = TIME STEP

Units: Month The frequency with which output is stored.

(76) social donation=IF THEN ELSE(effect of Paired Assistance Policy on social donation>0 , average social donation*effect of social identify on social donation*effect of resource allocation capacity on social donation*effect of government credibility on social donation*effect of Paired Assistance Policy on social donation, average social donation*effect of government credibility on social donation*effect of resource allocation capacity on social donation*effect of social identity on social donation)

Units: Billion/Month

This variable represents actual resource supplied by non-profit organizations each month. In the real practice, the resource supplied by non-profit organizations is not constant. It is affected by many factors, such as the Paired Assistance Policy, image of assisting parties, resource allocation capacity, government credibility and its social identity.

(77) social donation ratio=social donation/average social donation

Units: 1

This variable represents the difference between actual resource supplied by non-profit organizations and the resource expected supplied by non-profit organizations.

(78) Social identity= INTEG (change in social identity,0.5)

Units: Dmnl

This stock represents the citizen satisfactory of the public in the disaster area. Its value is 0.5 at the start.

(79) TIME STEP = 0.25

Units: Month

The time step for the simulation.

(80) Total resource demand=Initial reconstruction projects*required resource per project

Units: Billion

This variable represents the total number of resource needed by the post-disaster reconstruction. It is determined by the number of reconstruction projects and the resource needed by each project.

(81) Total resource supply= INTEG (accumulated resource supply,0)

Units: Billion

This stock represents the total number of resource supplied to the post-disaster reconstruction.