Building Resilience in Disaster Management Supply Networks through Cross-Sector Collaboration

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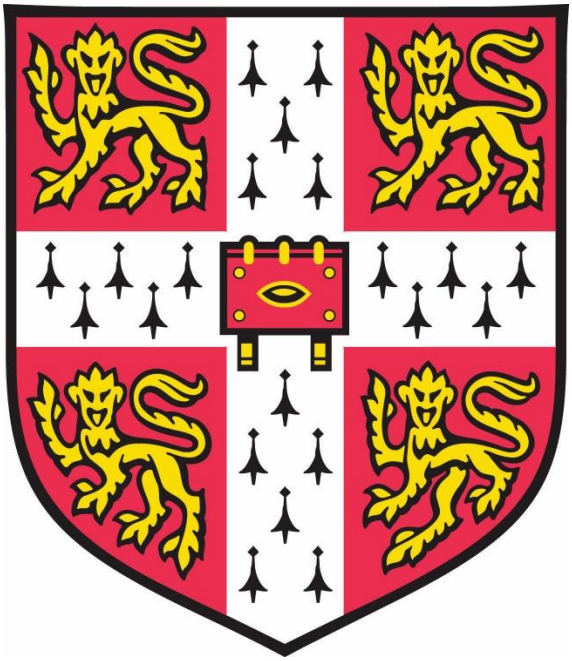

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Statement of Original Authorship

This dissertation is the result of my own work except as specified in the text work. It has not been submitted for previous assessment at the University of Cambridge or any other University or similar institution. It does not exceed the word limit of 15,000 words.

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Abstract

The increase in the frequency in disaster occurrence has pushed humanitarian actors and government agencies to create a more responsive disaster management system. Humanitarian actors and government agencies are the main players at the forefront of disaster management operations (DMOs). But what is the role of the private sector in disaster management operations which are equally affected by such calamities?

This dissertation analyses *resilience building* within *disaster management supply networks (DMSNs)* enabled by *cross-sector collaboration*, particularly focusing on the role of the private sector. Supply network resilience criteria are defined within the disaster management context – robustness, flexibility, velocity and visibility. DMSN capabilities characterising each resilience criteria are identified through the development of the DMSN Collaboration-Resilience (COLRES) Relationship Model. This theoretical model is applied to a case study of the Philippine DMSN to identify existing cross-sector collaboration activities. A causal analysis of each collaboration activity and its outcome is done to identify relationships between collaboration types and resilience constructs. Based on these results, patterns are identified and dependencies between collaboration and resilience are defined. Collective DMSN resilience (DMSNRES) enabled by existing cross-sector collaboration activities is evaluated against a future disaster scenario to identify resilience gaps. These gaps are used to identify new cross-sector collaboration opportunities, illustrating the continuous process of resilience building.

This dissertation ultimately finds that cross-sector collaboration builds resilience in DMSNs through capacity building, sourcing redundancy, information reliability, and logistics responsiveness. From literature, private sector collaboration operates within short-term donations in the form of money, logistics (e.g. lending of transportation assets), and procurement partnerships. However, this study shows that the private sector is able to go beyond these existing short-term partnerships by participating in collaboration activities within each disaster management phase in order to build resilience in disaster management supply networks.

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1. Introduction

The occurrence of disasters have since quadrupled in the last 10 years as compared to 50 years ago (CRED, 2019). The increase in the frequency in disaster occurrence has pushed humanitarian actors and government agencies to create a more responsive disaster management system in order to lessen casualties and economic costs brought about by these calamities (Beltrán Guzmán et al., 2019; CRED, 2018). Humanitarian actors and government agencies are the main players mandated to be at the forefront of disaster management operations (DMOs). But what is the role of the private sector in disaster management operations which are equally affected by such calamities?

Disaster management operations (DMOs) involve resource, financial and information flow throughout its phases – mitigation, preparation, response and recovery (Pujawan et al., 2009). The "ownership" of DMOs is most associated with the public sector (Matin, 2002). However, the complexities of disasters require multi-sectoral efforts as no single organisation has enough capacity to solely respond to all the needs of an affected region (Bui et al., 2000). Several studies have suggested that government collaborations with other sectors may help improve the efficiency of DMOs (Tomasini and Van Wassenhove, 2009; Maon et al., 2009; Balcik et al., 2010; Banomyong and Julagasigorn, 2017; Prasanna and Haavisto, 2018). Collaborations between the public sector and NGOs have already been institutionalised and are collectively known in literature as the humanitarian sector. However, there is still limited understanding as to how the private sector composed of businesses from different industries can be involved in a DMSN. To date, private sector's involvement in DMOs is limited to philanthropical financial contributions (Nurmala, 2018). Because of this, early researchers suggest that effective commercial supply network (CSN) strategies may also be applicable in the humanitarian context (Van Wassenhove, 2006; Oloruntoba and Gray, 2006; Kovács and Spens, 2007; Balcik et al., 2008), paving the way for the humanitarian supply network and logistics domain in the academe.

This dissertation then addresses a specific gap in the literature in disaster management by looking at how cross-sectoral collaboration, in particular between the humanitarian and the private sectors build resilience in domestic DMSNs.

The study is divided in seven chapters: First, the literature on disaster management supply network, supply network resilience and collaboration are reviewed where the research gaps are identified, which forms the basis for the research question (Chapter 2). The research methodology used to address the research question is then discussed (Chapter 3). The theoretical model for the analysis of collaboration and resilience relationships is developed in Chapter 4. This model is applied to a single case study in Chapter 5. The results are then analysed to validate the model and relate the findings back to the research objectives and literature (Chapter 6). This dissertation concludes with its contribution to knowledge and implications for further research (Chapter 7).

2. Literature Review

This literature review is structured into three main parts. First, it will discuss the big picture of the disaster management supply network (DMSN) studies, providing background on the complexities present within the humanitarian or disaster management context. Second, a review on supply network resilience literature is presented relating it to the disaster management context. Third, a review of supply network collaboration literature within disaster management is laid out. Following the discussion of the key themes, relevant frameworks are presented. The chapter will conclude with the identification of research gaps leading to the research question.

2.1. Big Picture: The DMSN

The Indian Tsunami in 2004 highlighted the importance of operations excellence in disaster management (Russell, 2005; ISM, 2005; Apta, 2009). 80% of the logistics activities were focused within disaster relief operations (Van Wassenhove, 2006). Logistics and supply chain management in disaster operations were at this point, not a priority for humanitarian actors (Özdamar et al., 2004) while in commercial operations, supply network management has been well established as a strategy to achieve cost-effectiveness in operations (Croxton et al., 2001). Cooper et al. (1997) emphasised that supply chain management goes beyond logistics and highlights the importance of some level of integration within and between cross functional teams.

2.1.1. DMSN Domain

A keyword search in SCOPUS was initiated to identify key themes in the study of Disaster Supply Networks:

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TITLE-ABS-KEY (disaster OR humanitarian ) AND TITLE-ABS-KEY ( "supply
chain*" OR "supply network*" )
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The search results were further limited to those published within the last 10 years, and within the area of business management, engineering, and decision sciences as other subject areas included energy, environmental science and earth and planetary sciences which were deemed irrelevant for the topic at hand.

Two key themes within the humanitarian context emerged from a bibliometric analysis (Figure 1) of the search results from SCOPUS: optimisation studies and network engineering studies.

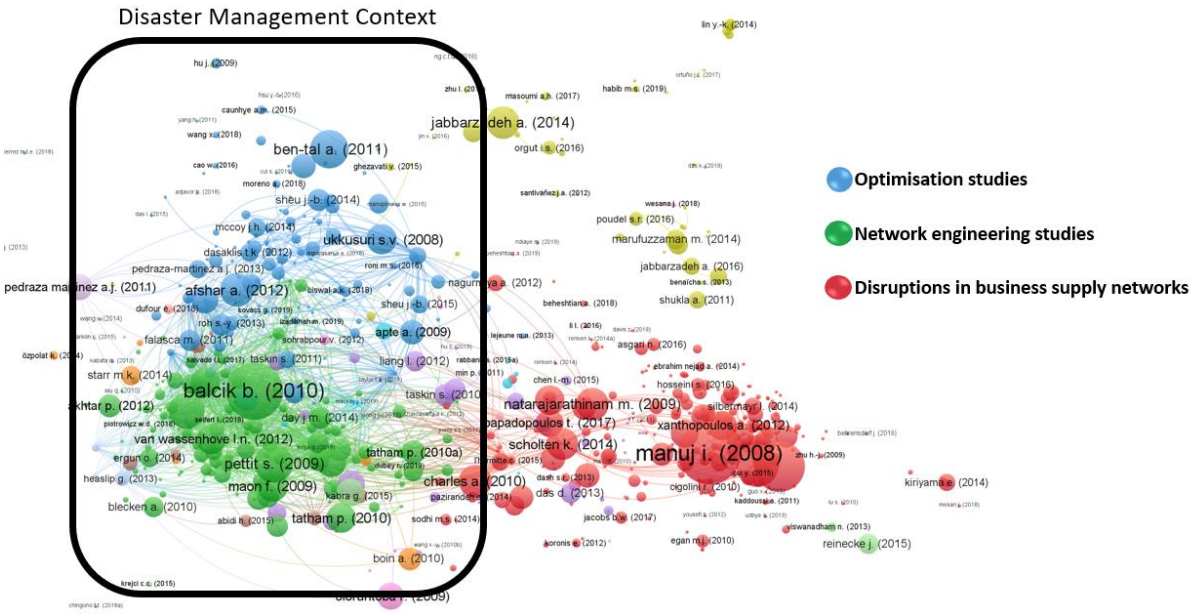

Figure 1. Bibliometric Network Mapping

Humanitarian logisticians encounter operational predicaments in relation to vehicle fleet management (Van Wassenhove and Pedraza Martinez, 2012; Afshar and Haghani, 2012; Manopiniwes and Irohara, 2017), vehicle routing and last mile distribution (Balcik et al., 2008; Elluru et al., 2017), facility location mapping for pre-positioning of relief items (Balcik and Beamon, 2008; Ukkusuri and Yushimito, 2008) and inventory stock management (Balcik et al., 2016; Toyasaki et al., 2017). All these studies have the objective of minimising operational costs. **Optimisation** methodologies mostly include operations research approaches such as linear programming and model simulation.

Network engineering studies looks at the DMSN domain from a strategic standpoint. The importance of collaboration between humanitarian stakeholders (Van Wassenhove, 2006; Maon et al., 2009; Kovács and Spens, 2009; Dolinskaya et al., 2011; Leiras et al., 2014; Tatham and Houghton, 2011) is highlighted in these studies. Procurement (Egan, 2010; Hu et al., 2019) and coordination mechanisms (Ergun et al., 2014; Gabler et al., 2017; Prasanna and Haavisto, 2018; Wiens et al., 2018) to achieve resilience.

A summary of the two key themes in DMSN studies are presented in Table 1.

Table 1. SN studies in Disaster Management Context

	OPTIMISATION	NETWORK ENGINEERING
DECISION LEVEL	Operational, tactical	Strategic, tactical
CHALLENGES	Facility planning, Inventory management, Last mile distribution, Decision-making, Resource allocation	Collaboration, Lack of resilience, Lack of agility, Turbulent information and relief flows, Procurement and supplier relations
OBJECTIVE	Minimise operational cost	Resilient supply chain

2.2. Differentiating DMSNs from CSNs

While there are similarities between CSNs and DMSNs, the difference in context for each network poses complexities for DMSNs (Table 2). Unpredictability tops the list characterising a DMSN. It pertains to the disaster type, intensity, time, location and demand requirements (Hellingrath et al., 2013; Olaogbebikan and Oloruntoba, 2017). This in turn results to the very short lead times imposed on DMSN actors and the need to always act with urgency. Furthermore, DMSNs are characterised by higher stakes involved should disasters would not be handled well. Welfare of the communities are at stake which includes possible displacement from their residences, injuries, loss of livelihood and even lives. Turbulent environment characterised by lack of invariable sources of critical resources and as well as sporadic information flow continue to burden the establishment of stable processes within disaster operations context.

Table 2. Complexities in Humanitarian Supply Chain

		Complexities											
		Unpredictability	Short lead time	High stakes	Turbulent environment	Sporadic information flow	Infrastructure damage	Coordination	Human Resources	Funding	Supplier structure	Geographical dispersion	Lack of standards
Authors	Oloruntoba and Gray, 2006	x			x	x						x	
	Van Wassenhove, 2006	x											
	Kovács and Spens, 2007		x	x			x				x		
	Maon et al., 2009	x	x	x		x	x	x				x	
	Kovács and Spens, 2009						x	x	x				x
	Overstreet et al., 2011	x	x				x		x	x			
	Hellingrath et al., 2013	x	x		x	x					x		
	Olaogbebikan and Oloruntoba, 2017	x	x	x		x		x		x			
	Gatti, 2017		x	x	x				x	x			

2.3. Disaster Supply Network Resilience

Supply Network Resilience (SNRES) is *capability of the supply network to prepare for unexpected events, respond to disruptions, and recover from them* (Ponomarov and Holcomb, 2009). As such, it is all the more important for DMSNs to be resilient since it is the backbone of relief activities responding to disruptions caused by natural disasters. An initial keyword search in SCOPUS was done to understand the current state of academic literature in this domain. Review methodology is outlined in Figure 2 which resulted to 41 peer-reviewed documents.

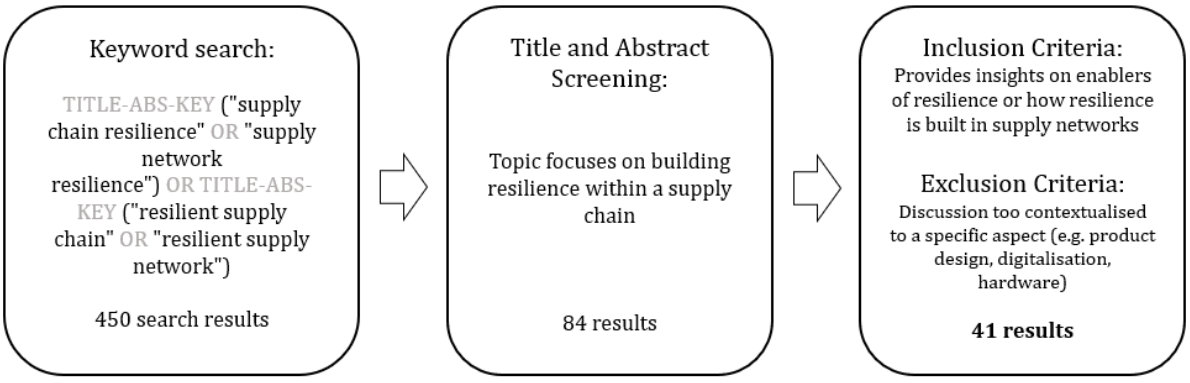

Figure 2. Review methodology for Supply Network Resilience domain in SCOPUS.

From the review of these 41 documents, it was found that only 5 journal articles addressed the disaster or humanitarian management context. Therefore, research on the application of resilience in disaster supply networks can be said to be scant until now.

The discussion will explore the concept of supply network resilience, mostly within a commercial context and how they can be related to the DMO context.

Twenty-three resilience constructs were identified from the review of the literature and are summarised in Table 3. Careful to note however, that authors have varied understanding of the constructs where a first-order construct for one author, may be a second-order construct to others. To demonstrate, redundancy is seen to be either a construct to achieve flexibility (Sheffi and Jr, 2005; Jüttner and Maklan, 2011; Dubey et al., 2014) or a pillar separate from flexibility (Tukamuhabwa et al., 2015; Hohenstein et al., 2015; Chowdhury and Quaddus, 2016; Ivanov and Dolgui, 2018). On the other hand, Välikangas (2010, p.19) showed that most enablers identified within the literature falls within these only main constructs – robustness and agility. This finding was a basis of many other studies focusing the discussion to either robustness (Durach et al., 2015) or agility (Dubey et al., 2014; Gligor et al., 2019; Rasouli, 2019) as main enablers of resilience.

The identified resilience constructs were found to be applicable within the disaster context as well (Scholten et al., 2014). Day, (2014) proposed that resilience encompasses the all disaster management phases where the flow of resources, information and finances should be coordinated. Singh et al. (2018) identified activities such as government support, strategy and capacity planning, and continuous assessments in building DMSN resilience (DMSN Res).

Based on Table 3, collaboration ranked the highest out all construct, followed by visibility, flexibility, and agility. However, agility is not clearly defined in literature. It may pertain to velocity, or as a collective construct for flexibility, visibility and velocity, or as a separate construct. Hence, velocity is considered instead to minimise overlaps with the other constructs in discussions. This is in line with the constructs set forth by Jüttner and Maklan, (2011). Visibility refers to being able to see all relevant information such as location of supply network members or status of products and services (Johnson et al., 2013). Flexibility refers to having viable alternatives such as back-up suppliers, manufacturing facilities, and multi-skilled workforce (Sheffi and Jr, 2005). Velocity refers to the pace of response towards a disruption (Jüttner and Maklan, 2011). Collaboration pertains to the ability to effectively deal with issues which may not be tackled by any entity alone (Jüttner and Maklan, 2011). It may involve social constructs such as trust,

norms, obligation identification, shared and reciprocity (Johnson et al., 2013). Although collaboration ranked the highest resiliency enabler, studies focusing on its influence on SNRES is scarce.

Table 3. Constructs of Supply Chain Resilience

	Collaboration	Visibility	Flexibility	Agility	Velocity	Robustness	Anticipation	Adaptability	Risk Management	Knowledge Mgt	Preparedness	HR Management	Sustainability	Recovery	Transparency	Culture	Leadership	Innovativeness	Trust	Data Analytics
Ponomarov and Holcomb, 2009	x	x	x	x	x	x	x								x					
Jüttner and Maklan, 2011	x	x	x		x				x											
Hearnshaw and Wilson, 2013								x												
Scholten et al., 2014				x					x	x										
Wieland and Wallenburg, 2013		x		x	x	x	x				x									
Tukamuhabwa et al., 2015	x		x	x																
Hohenstein et al., 2015	x	x	x	x								x								
Scholten et al., 2014	x																			
Christopher and Peck, 2004	x	x		x	x	x										x				
Day, 2014	x	x				x			x			x					x			
Rasouli, 2019				x																
Golgeci and Ponomarov, 2013																		x		
Gunasekaran et al., 2015	x	x	x	x	x	x	x	x												
Jain et al., 2017	x							x					x						x	
Ali et al., 2017		x	x	x	x	x	x	x		x										
Soni and Jain, 2011	x	x	x					x					x							
Namdar et al., 2018	x	x																		
Ivanov and Dolgui, 2018			x			x														
Chowdhury and Quaddus, 2016	x	x	x		x						x			x						
Dubey et al., 2019																				x
Treiblmaier, 2018				x										x						
Dubey et al., 2014	x		x		x															
Sá et al., 2019	x	x	x				x	x												
Total	14	12	11	10	8	7	5	5	3	2	2	2	2	2	1	1	1	1	1	1

In contrast to Jüttner and Maklan, (2011), Scholten and Schilder, (2015) argued that collaboration is an antecedent of visibility, velocity and flexibility, proposing it as a second-order enabler to resilience (Figure 3); emphasising its importance to in improving the other three constructs. In the context of DMSNs, multiple actors are involved; each serving different purposes and are motivated by different factors.

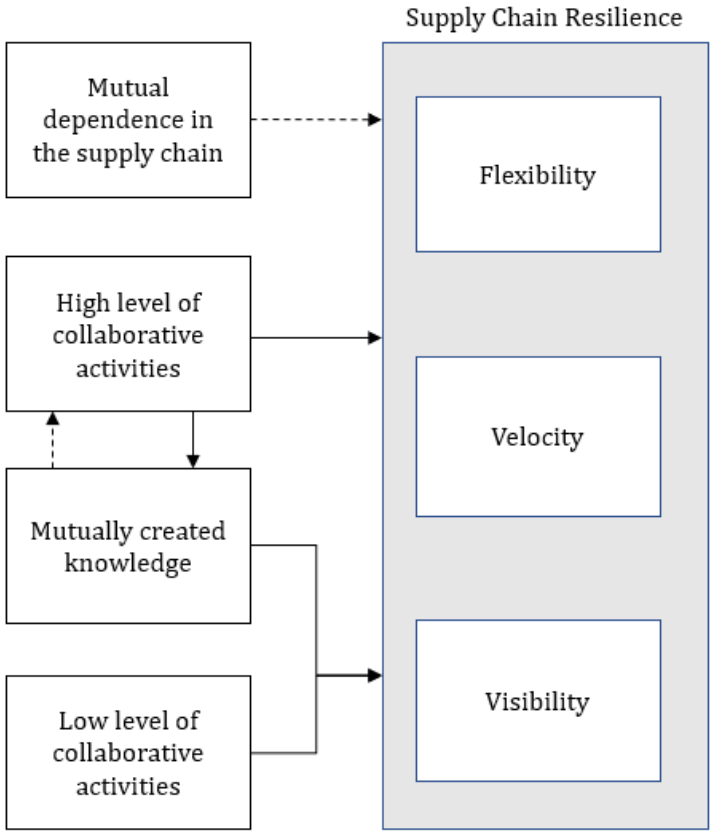

Figure 3. Influence of Collaboration on Supply Network Resilience (Scholten and Schilder, 2015)

2.4. Collaboration in DMSNs

Supply network collaboration enables resilience (Scholten and Schilder, 2015) which is a key factor in DMSNs (Tang, 2017; Masood et al., 2017). In a DMSN, multiple actors are involved in a disaster event. No single actor has sufficient resources to respond effectively to a major disaster (Bui et al., 2000). However, the complexity of a disaster environment does not necessarily encourage collaboration (Balcik et al., 2010) and hence continued to be a fundamental weakness of humanitarian organisations. One explanation for this is because in contrast to CSN where the actors have aligned incentives, DMSN actors have more or less misaligned motivations for being involved in DMOs (Hellingrath et al., 2013).

Cozzolino (2012) provided an overview of the actors in DMOs through a humanitarian relationships model (Figure 4). Apart from the donors, these actors can be summarised into three key sectors, namely, the public, socio-civic, and private sectors (Waddell and Brown 1997).

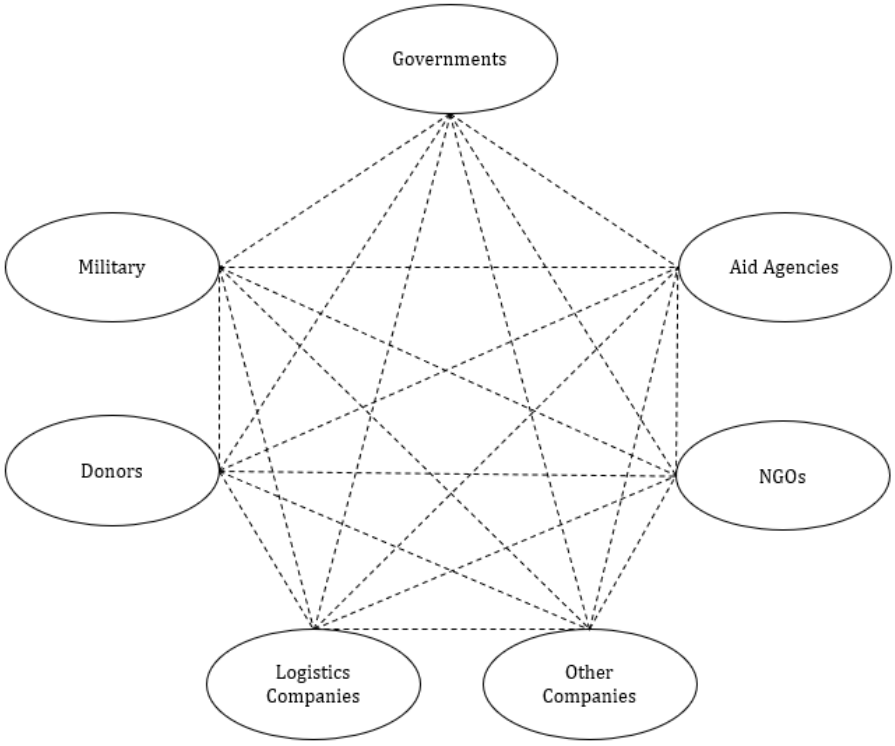

Figure 4. Humanitarian Relationships Model (Cozzolino, 2012)

Cao and Zhang (2011) identified supply network collaboration activities as *information sharing, goal congruence, decision synchronisation, incentive alignment, resource sharing, and joint knowledge creation.* This classification of collaboration activities can be used to identify existing cross-sector collaboration activities within a DMSN.

2.4.1. Key Sectors within DMSNs

a) Government (Public Sector) - It is the general public perception that the government has the sole responsibility for conducting relief operations while other actors only abide (Balcik et al., 2010). However, public authorities do not usually have all the capacities and resources, especially transportation assets and logistical competence to singlehandedly manage DMOs

b) Non-government Organisations (NGOs or Socio-civic Sector) - Socio-civic organisations, more commonly referred to as non-governmental organisations (NGOs),

are regular participants in DMOs as well. Characterised as neither part of a governmental office, nor a for-profit business organisation, NGOs provide opportunities for citizens to volunteer in social work and development. NGOs usually are members of international organisations with national chapters in different countries. These organisations are already used to working hand-in-hand with the governments especially when a national state of calamity is declared in a disaster-stricken region.

c) Commercial Businesses (Private Sector) - The private sector is defined as commercial businesses operating for profit. This includes manufacturing firms, third-party logistics, utilities and the likes. Several studies already explored the role of the private sector in disaster management operations (Wu Qiao et al., 2010; Koliba et al., 2011; Chen et al., 2013; Izumi and Shaw, 2014; Gabler et al., 2017; Nurmala et al., 2018). Private firms, do not only serve their direct customers but also acknowledge their existence as part of a community and a bigger society (Swanson and Smith, 2013).

2.4.2. Roles within Disaster Management Supply Network

Wiens et al. (2018) summarised the roles of the three main sectors (Table 4) within the DMSN. It can be observed that collaboration between public sector and NGO collaboration has already been established. The private sector is, however, found to be providing occasional support through donations and services as well as a partner in keeping critical infrastructure functioning in light of the privatisation of these assets.

Table 4. Roles of each sector in Disaster Management Supply Network (Wiens et al., 2018)

	Private Sector	Public Authorities
Roles in Commercial Supply Network	Key actors of supply network and drivers of market allocation Critical Infrastructure operator	Regulator of market Client/Buyer Critical Infrastructure operator
Roles in Disaster Management Supply Network	Mainly passive roles Cooperative as Critical Infrastructure operator Occasional support (e.g large distance transport)	Key responsible body for crisis management and civil protection Cooperation with NGOs Military support

The public sector and humanitarian NGOs are said to be experts in welfare assessment rather than logistics or operations management (Wang et al., 2016). This brought about several empirical studies exploring existing partnerships between the private sector and the humanitarian sector. Banomyong and Julagasigorn (2017) discussed philanthropic

collaboration where a multi-national company provided transportation assets to deliver the water filtration equipment sourced by an NGO. Long-term partnerships were also identified, particularly the "Moving the World" initiative of TNT, a third-partly logistics company and World Food Programme (WFP) (Tomasini and Van Wassenhove, 2009). Beyond disaster response, the role of the private sector in disaster preparedness and mitigation are said to be feasible, especially in the fields of construction, infrastructure and telecommunication (Izumi and Shaw, 2014). While there are few good cases of private sector involvement in disaster management, Nurmala et al. (2018) manifested however, that most of the private sector involvement is still limited to philanthropical financial contributions.

2.5. Resilience Framework

Masood et al. (2017) introduced the Disaster Resilience in Supply Chain Operations (DROPS) Framework (Figure 5), as a result of a 5-day international workshop on disaster resilience involving multi-sectoral humanitarian experts. The said framework touches on many relevant considerations enabling holistic analysis of a DMO, which has not been found in other literature. While the framework allows comprehensive examination of DMOs, this study pays specific attention to cross-sector collaboration within the DMSNs only and will therefore be contextualised accordingly for a more focused analysis.

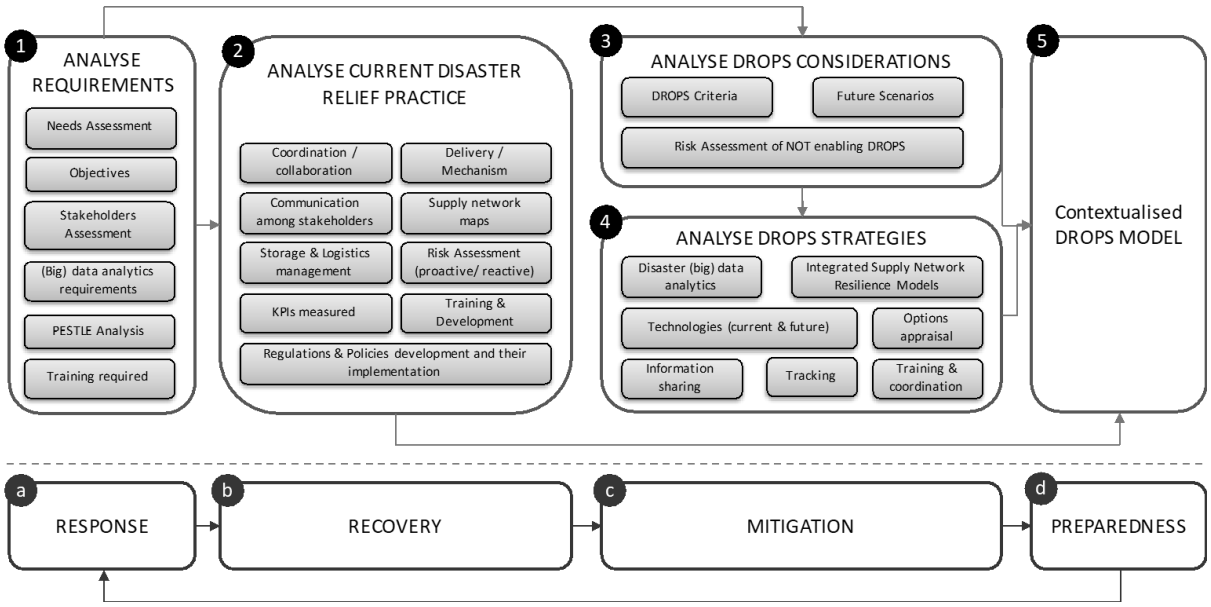

Figure 5. The DROPS Framework (Masood et al., 2017)

2.6. Research Gap

Current literature has established CSN management practices may be applicable to DMSNs as well (Van Wassenhove, 2006; Oloruntoba and Gray, 2006; Kovács and Spens, 2007; Balcik et al., 2008). **However, building supply network resilience within the disaster management context has not yet been fully explored.** This gap is also recognised by a number of researchers who managed to contribute DMSNRES studies in the recent years (Scholten et al., 2014; Day, 2014; Singh et al., 2018; Rasouli, 2019; Dubey et al., 2019).

With the growing size of literature in supply network resilience, collaboration has been found to be among the top enablers of SNRES (see Chapter 2.3.). While there are also wide variety of studies focusing on supply network collaboration, **there has been scant literature focusing on how supply network collaboration can influence CSN resilience** (Scholten and Schilder, 2015)**, more so on DMSNRES.**

Focusing on collaboration within the DMSN, the role of the private sector has been discussed in humanitarian partnerships or collaboration literature but has been **limited mostly to procurement partnerships, philanthropic involvement such as financial contribution and service offering mostly for transportation of goods between single private firm and a single NGO.** This gap is recognised by Nurmala et al. (2018) highlighting that current humanitarian-business partnerships has the potential to go beyond such short-term involvements.

Thus, a conclusion is drawn that **cross-sector collaboration in disaster management has potential to be further explored. Further, its influence on DMSNRES has not yet been addressed.**

2.7. Research Questions

Following the research gaps, the main research question is formulated as follows:

> **How can resilient disaster management supply networks be built through cross-sector collaboration?**

To answer the main question stated above, the following sub-questions were developed:

> SQ1: How can cross-sector collaboration in DMSNs be analysed in a resilience perspective?

SQ2: Where is cross-sector collaboration practiced within the DMSN?

SQ3: What are the implications of the existing cross-sector collaboration activities on resilience within DMSNs?

To address the sub-questions, the following research objectives are intended to be achieved.

RO1: Develop a theoretical model than can be used to analyse cross-sector collaboration and its influence on DMSNRES

RO2: Identify existing cross-sector collaboration activities within each disaster management phase

RO3: Identify causal relationships between cross-section collaboration and DMSNRES

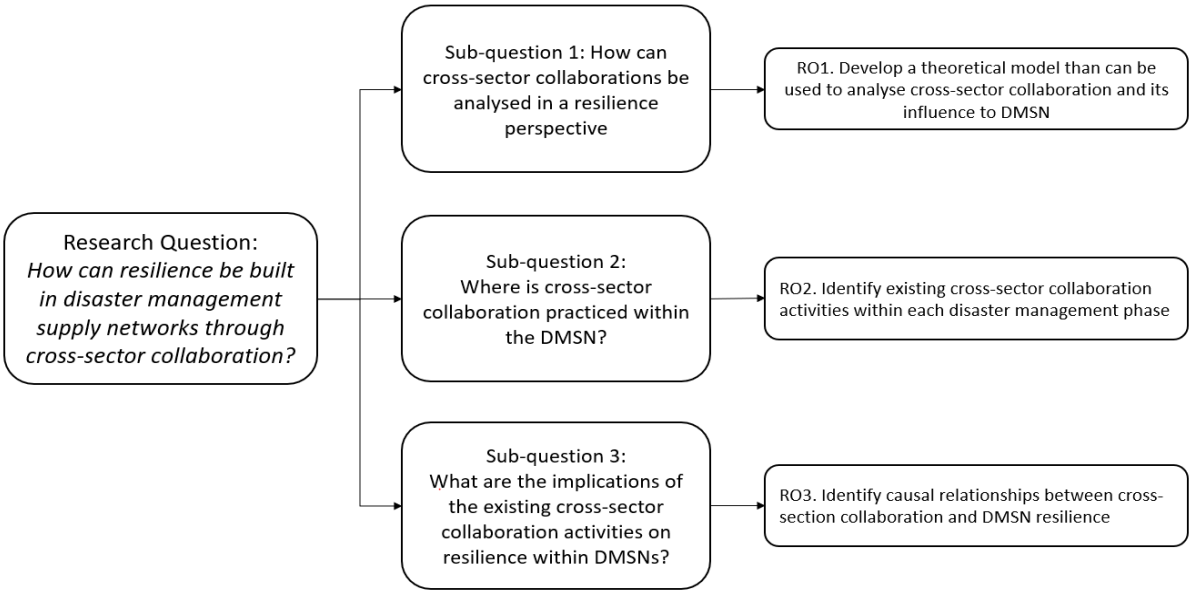

Figure 6. Linking Research Question, Sub-questions, and Objectives

3. Research Methodology

3.1. Research Approach

The first part of this dissertation uses deductive research approach to develop a theoretical model **(RO1).** The theoretical model developed in this study draws from the existing conceptual DROPS framework (Masood et al., 2017), but contextualised to focus on cross-sector collaboration within the DMSN. The theoretical model identifies specific cross-sector collaboration activities within each disaster management phase **(RO2)** and how these activities can influence DMSNRES **(RO3)**.

While building the theoretical model, an inductive research approach is used to investigate how cross-sector collaboration can be linked to DMSNRES. The resulting theoretical model will then be applied as a research tool to the empirical study, again following a deductive approach.

3.2. Research Design

It is acknowledged that in choosing the most appropriate research design, the process of selection should be guided by the main research question and specific objectives, the findings and gaps of the literature reviewed, and consideration of the amount of time and resources available to the researcher (Saunders et al., 2009). As discussed in previous chapters, this study looks at cross-sector collaboration in DMSN by mapping existing cross-sector collaboration activities implemented and how these can influence resilience building in DMSNs. Given these considerations, the following criteria guided the research design selection:

1. Adaptability to contexts – allows the empirical validation of the theoretical model while paying attention to the specificity of the context investigated
2. Convenience for the respondents – enables respondents to conveniently explain their disaster response processes requiring less time or resources
3. Reliability of data – to avoid outdated processes and reflect current actual scenario
4. Ease of execution – considering limited time and resource for the researcher
5. Response rate – assures high response rate from respondents
6. Opportunity to clarify or follow-up – allows respondents to clarify questions as well as for the researcher to ask follow-up questions

Existing studies on supply network management have employed several established empirical research methods namely, interviews, surveys, simulations, content analysis of existing academic literature, news articles, and organisation websites (Nurmala et al., 2017; Papadopoulos et al., 2017); case studies (Tang, 2017; Cozzolino et al., 2012; Matin, 2002; Banomyong and Julagasigorn, 2017). Table 5 lists these methods and scores their relevance according to the study's research method selection criteria. It shows that case study is the most fitting research design to answer the main research question. The use of case study provides the opportunity to look at the collaboration activities existing between several actors (Baxter and Jack, 2008) involved within the DMSN. These are public sector, NGO sector, and private sector.

Table 5. Selection of Research Method

		Research Methods			
		Content Analysis	Surveys	Simulations	Case Study
Criteria	Analysis of empirical evidence	-	+	+	+
	Convenience for respondents	+	-	+	+
	Reliability of information	-	o	-	+
	Ease of execution	+	o	-	+
	Response Rate	-	-	o	+
	Opportunity for follow-up	-	-	+	+

Legend: (+) satisfies criteria; (-) fails criteria; (o) neither satisfy nor fail

Given the research method selection criteria defined for this study, the most appropriate research method is deemed to be the case study. The fit of the research question to the research strategy is an important aspect in research strategy selection. Yin (2003) discussed that case studies are applicable to studies exhibiting the following characteristics: (a) research questions which aims to answer a "How" or "Why" question; (b) when behaviours of the actors cannot be manipulated by the researcher; (c) when contextual conditions are believed to be relevant to the phenomenon and therefore have to be covered; and (d) the boundaries between the phenomenon and context are not clear. This study examines contemporary phenomena which is cross-sector collaboration within DMSNs. It is important to note that several research strategies are not mutually exclusive. In this study, a case study may be facilitated using semi-structured interviews or surveys as the tool for data gathering.

3.3. Case Study Selection

In choosing a case to investigate, guidance from the Sendai Framework is taken, where it was emphasised that resilience should be built across international, national and local contexts (UNDRR, 2015). At the same time, the World Disasters Report 2018 also identified the unaddressed complexities of global management of disasters and emphasised the need to strengthen domestic DMOs (IFRC, 2018). With this in mind, this study looks specifically at one domestic context.

The **case study country selection criteria** are defined as follows:

- Relevance of site to the study– frequency of natural disaster occurrence and vulnerabilities from natural disasters
- Participation in the Connecting Business initiative - specific organisations from the public, socio-civic and private sectors can be identified
- Access to contacts – connections to relevant organisations are available

The top five countries most hit by natural disasters in the last ten years are the United States, China, the Philippines, India and Indonesia (CRED, 2019). Among these five countries, the Philippines, India and Indonesia ranks the least in terms of economic standing based on GDP per capita (IMF, 2019). It is said that the middle-income countries accumulate higher risks since there is rapid economic growth but the institutional capacity to manage resources are not developing at the same pace (The World Bank, 2017). Hence, relevance of this specific study is deemed to be higher for those countries in the lower economic standing. As the researcher is from the Philippines, relevant contacts are readily available through connections from colleagues. Table 6 summarises the selection criteria where the Philippines has been chosen as the site for this case study.

Table 6. Selection of Case Study Country

Country	Average occurrence of natural disasters per year	Participation in CBi*	Relevance of the study to the site	Access to relevant contacts
China	30	-	0	-
United States of America	23	-	0	-
Philippines	**18**	**+**	**+**	**+**
India	16	+	+	-
Indonesia	13	+	+	-

*Source: CBi (2019) | Legend: (+) satisfies criteria; (-) fails criteria; (o) neither satisfy nor fail

3.4. The Philippine Disaster Profile

The Philippines ranks second on the greatest number of people affected by disasters in 2018 (approximately 6.5 million people) (CRED, 2019). Much of the natural disaster risk in the Philippines is due to its geographical profile. The Philippines, being situated near the equator and the largest ocean in the world, is part of the region having the warmest ocean temperature globally which boosts the formation of typhoons. Figure 7 illustrates all the tracks of the tropical cyclones which made landfall in the country from 1966 to 2016 (UP NOAH, 2016).

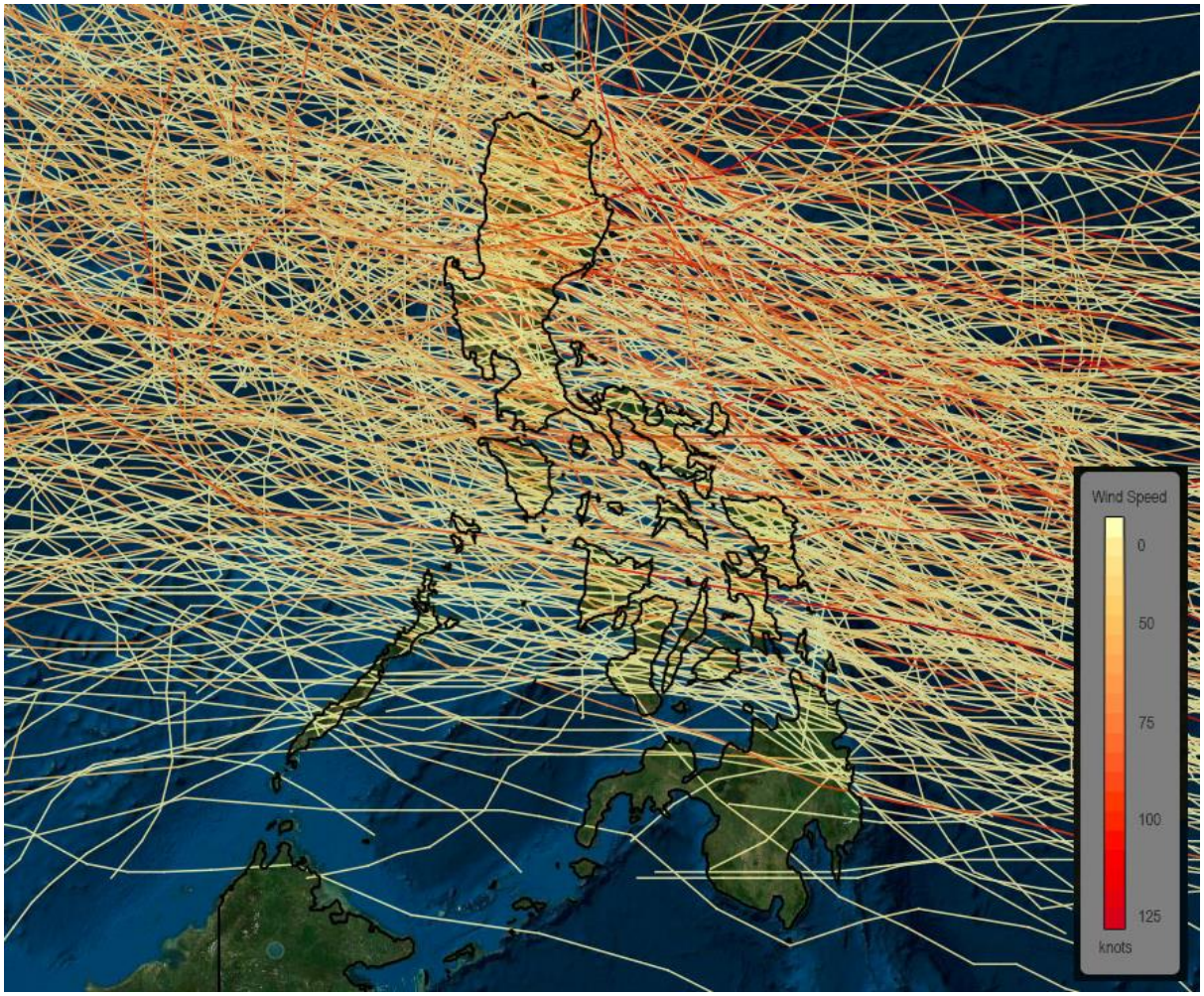

Figure 7. Track of the Tropical Cyclones to have made landfall from 1966 to 2016 (UP NOAH, 2016)

Aside from frequent typhoons, the country also experiences earthquakes due to its location at the Pacific Ring of Fire. According to the Philippine Institute of Volcanology and Seismology (PHILVOLCS), there are 23 active volcanoes in the country. While occurrence of earthquakes is frequent due to the country's geographical location, damaging earthquakes were less than 10% of the total natural disasters which occurred in the last ten years (CRED, 2019). Figure 8 illustrates earthquake occurrences in the Philippines in the last twenty years (UP NOAH, 2019).

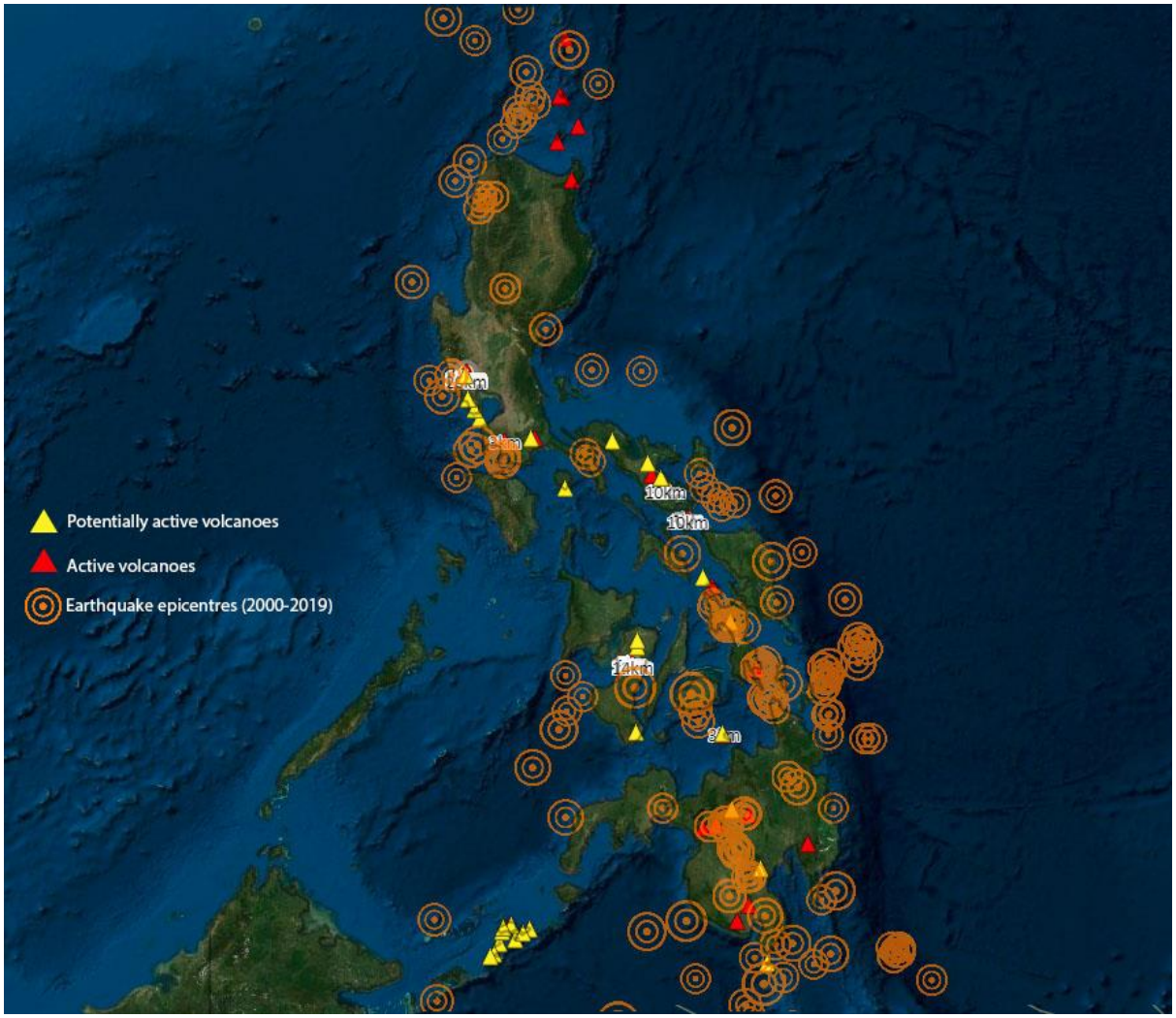

Figure 8. Mapping of Philippine volcanoes and historical earthquakes (2000-2019) (UP NOAH, 2019)

The above facts raise the greater need to properly manage disaster operations in the Philippines. Its National Disaster Response Plan (NDRP) was updated last 2018 headed by the National Disaster Risk Reduction and Mitigation Council (NDRRMC).

Under the NDRRMC are smaller and localised DRRMCs organised based on geographical scope (NDRRMC Response Cluster, 2016). The smallest unit of organisation is *barangay* [village] level, which is a group of households in close proximity to one another. Cities or municipals are groups of barangays; hence, if multiple barangays are affected by a disaster, the local responsibility is with city or municipal DRRMCs. Same principle applies to provincial DRRMCs, as the province is a group of several cities and municipals. A region in the Philippine context is a collection of several provinces. Regional DRRMCs report directly to the NDRRMC.

3.5. Data Collection

Data collection was done using semi-structured interviews. This method allows for a flexible approach to the interview process while building rapport with respondents. Semi-structured interviews allowed the researcher to clarify and probe which helped gather more information about their experience in cross-sector collaboration. While there is flexibility in this data collection method, structure is maintained to avoid the discussion from drifting away from the main research topic.

The researcher approached organisations from key sectors: the public sector, the socio-civic or NGO, and private sector. These sectors offer diverse perspectives given the differences in their daily operating environments. The researcher purposely selected organisations which already had sufficient experience in the Philippine disaster response operations to build confidence on the results of the study banking on the respondents' expertise. The country's NDRP was used to help identify key organisations within each key sector.

For the public sector, a governmental department (C1) was chosen given their mandate of leading the disaster response and relief efforts of the country. A national-level NGO (C2) was chosen as the agency under the NGO sector since its collaboration with the public sector has already been institutionalised in the NDRP. Moreover, it is the only NGO given a permanent seat within the NDRRMC. Lastly, the Philippine Disaster Resilience Foundation (PDRF) was chosen and identified as an emerging private sector network for disaster resilience and is part of the CBi. PDRF is composed of business organisations from eight clusters (power, fuel & energy, telecommunications, water and sanitation, food and non-food, logistics, medical services, finance, and infrastructure) providing support in disaster operations. Aside from support in response, PRDF offers business continuity planning modules for its member companies.

The interview questions can be found in the appendix section. The organisations interviewed were asked for a representative actively involved in DMOs to join the interview session. Their details are provided in Table 7.

Table 7. Details of respondents interviewed in the case study

Organisation	Sector	Respondent Position in the Agency
C1	Public	Division Chief- Logistics Management Division National Resource and Logistics Management Bureau
C2	NGO (Socio-civic)	Logistics officer – Disaster Management Service
		Program coordinator – Disaster Response Unit
		Program coordinator – Disaster Recovery Unit
		Program coordinator – Disaster Preparedness Unit
PDRF	Private Sector	Operations Centre Director
		Recovery Program Manager
		Geohazard and Spatial Information Manager

*Note: Due to conflicts in schedules, only one interviewee was available from the C1

Respondents were asked their consent for the interview to be recorded. However, in some interviews where the approval was not taken, the researcher opted to take notes instead.

3.7. Data Analysis

The DROPS Framework was used to analyse cross-sector collaboration with guidance from the supply network collaboration activities identified by Cao and Zhang (2011). From these, the resulting DMSN Collaboration-Resilience (COLRES) framework (Figure 9) informs the creation of the theoretical model discussed in Chapter 5 which illustrates how cross-sector collaboration helps in resilience.

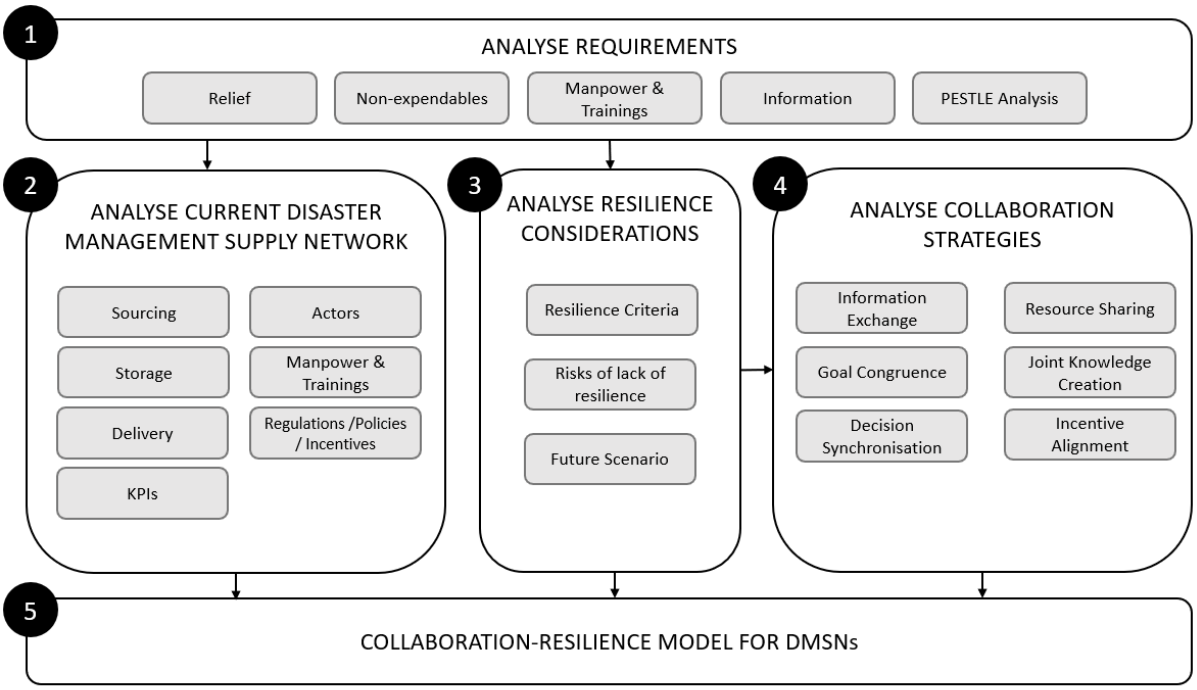

Figure 9. DSMN COLRES Framework

The collaboration-resilience model developed will be used for data collection and analysis on an explanatory case study. Causal relationships will be analysed to link cross-sector collaboration activities and the resilience criteria. Patterns will be deduced from the analysis which will form the basis of the discussion.

3.8. Research Methodology Roadmap

The study's research methodology roadmap is summarised in Figure 10. RO1 will be addressed through the case study, involving the development and usage of the theoretical model. RO2 and RO3 are addressed by analysis of the findings from the theoretical model.

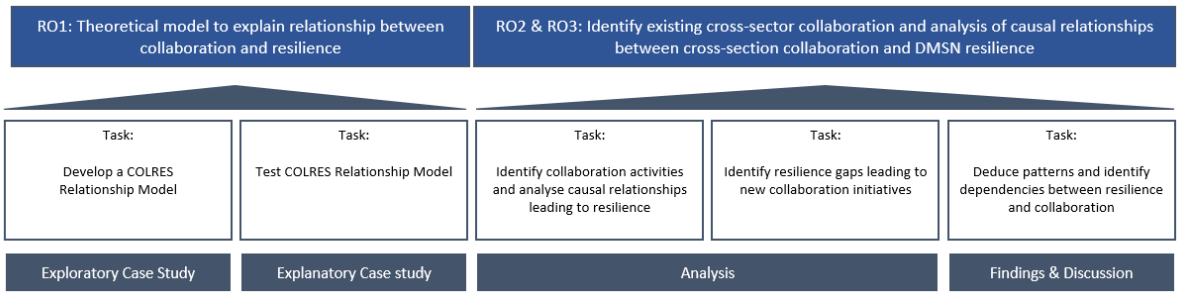

Figure 10. Research Methodology Summary

4. Theoretical Model Development

As mentioned in Chapter 3.7, the DMSN COLRES framework (Figure 9), is used on an exploratory case study to ultimately develop a theoretical model illustrating the relationship between collaboration and resilience within DMSNs. This was done by understanding how resilience is defined within the DMSNs and how the existing cross-sector collaboration activities are characterised in DMSNs. The discussion in this section follows five main components of the DMSN COLRES framework.

4.1. Analyse Requirements

Respondents identified the top resources that are needed within DMSNs. Relief items were identified to be family food packs, water, and evacuation kits. Beyond the relief items, non-expendable resources that would enable better disaster management are necessary as well. These are emergency communication devices, power sources, transportation equipment and infrastructure equipment. Manpower is also throughout the whole supply network. This includes but is not limited to operations managers, incident commanders, medical responders, relief distribution teams and community volunteers. Reliable information is also critical in DMSNs as it triggers the movement of resources from one site to another. Tons of information flows through the DMSN in many different directions. Processing of big data into relevant information can enable the fast distribution of the right resources in the right location at the right time and at the right quantity.

Aside from the assessment of immediate resources needed for effective disaster response, specific requirements may be suitable to a disaster scenario. A PESTLE analysis may be done to assess the environmental situation on the ground. This is highly relevant to the case of the Philippines where disaster management is very much politically loaded given the responsibilities given to government officials to facilitate the whole operations. Economic and social well-being are also assessed in a given disaster scenario to identify interventions that can be provided by the responders.

4.2. Analyse Current Disaster Management Supply Network

The process by which the identified resources flow within the DMSN are analysed in this section. During white alert (low risk) status, PDRF, C1 and C2 all focus their attention to capacity building. Preparation activities such as procurement and pre-positioning should

also be done to facilitate faster response should a disaster occur. Both C1 and C2 have their own contract suppliers for relief items. Both are practicing pre-positioning of items in regional relief warehouses. C1 focuses on pre-positioning 30,000 food packs in each of their 16 regional warehouses across the country. C2 also pre-positions evacuation kits in 10 warehouses across the country at varied inventory capacities. As the number of C2 warehouses are not enough to fill each of the country's 16 regions, clustering of provinces assigned to each warehouse are done as well.

The military is able to provide for the logistical resources such as trucks during disaster response. C1 also has pre-arranged agreements with third party logistics companies. Ad-hoc participation of private companies with their own transportation assets are also observed to augment capacity. C2 have its own logistical resources to transport their relief items to disaster sites. Communication means as well as the power sources go hand-in-hand as critical utilities that are not only of urgent necessity for the calamity victims, but also for the first responders on the scene. Like most countries, these means are supplied by private telecommunications and electric companies and regulated by the government. Figure 11 provides an overview of resource flow in the Philippine DMSN.

Upon occurrence of a disaster, the National Disaster Response Plan will be activated to provide general direction for all government agencies and networks involved in disaster risk reduction and management council. An incident command system (ICS) will be set-up based on the scope of the impact of the disaster. It will be the main coordinating body in-command and will be responsible for managing all operations on the affected site. All response teams on the disaster site must report to the ICS. Figure 12 summarises information flows within the disaster supply network

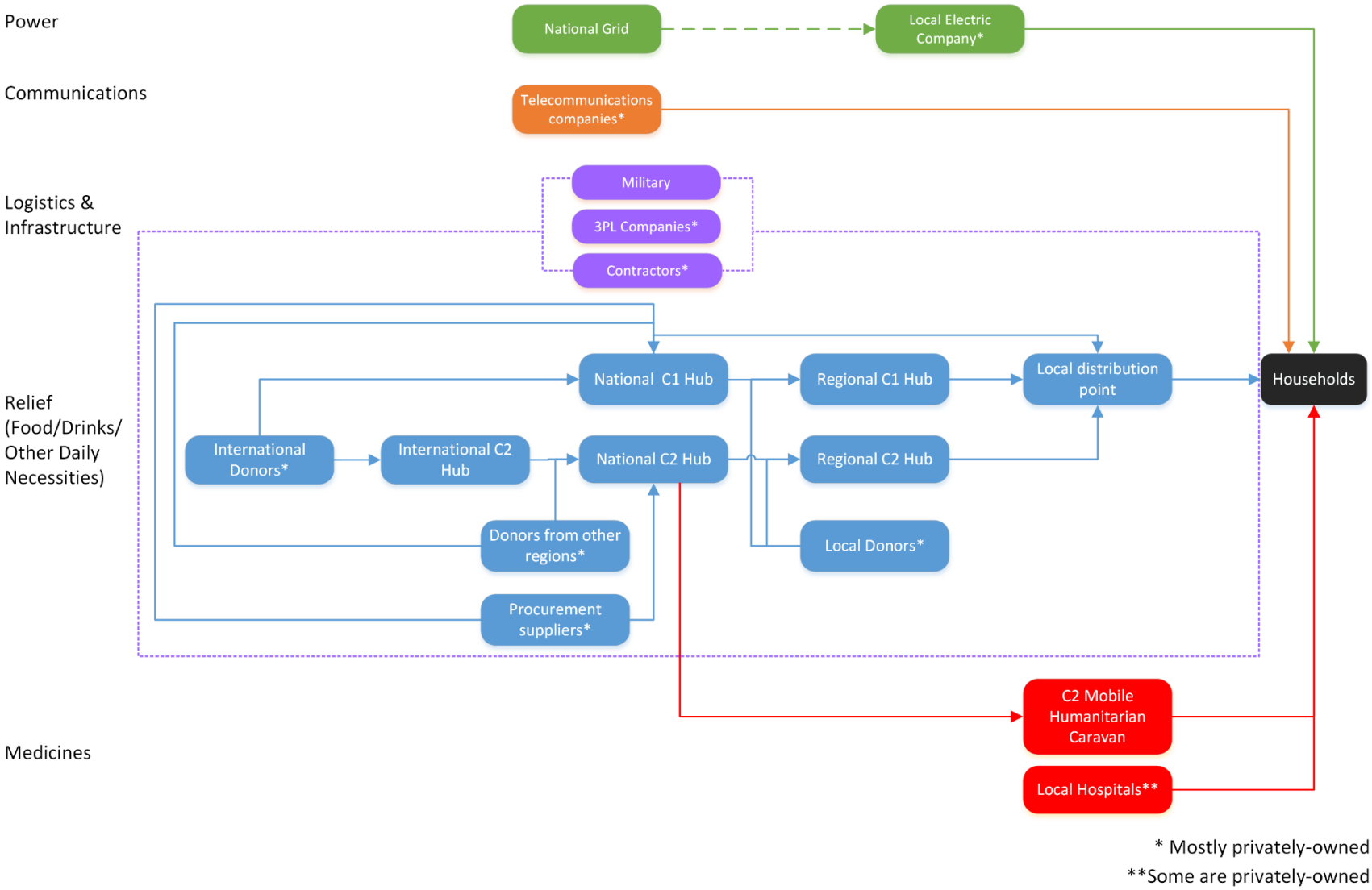

Figure 11. Resource Flows in Philippine DMSN

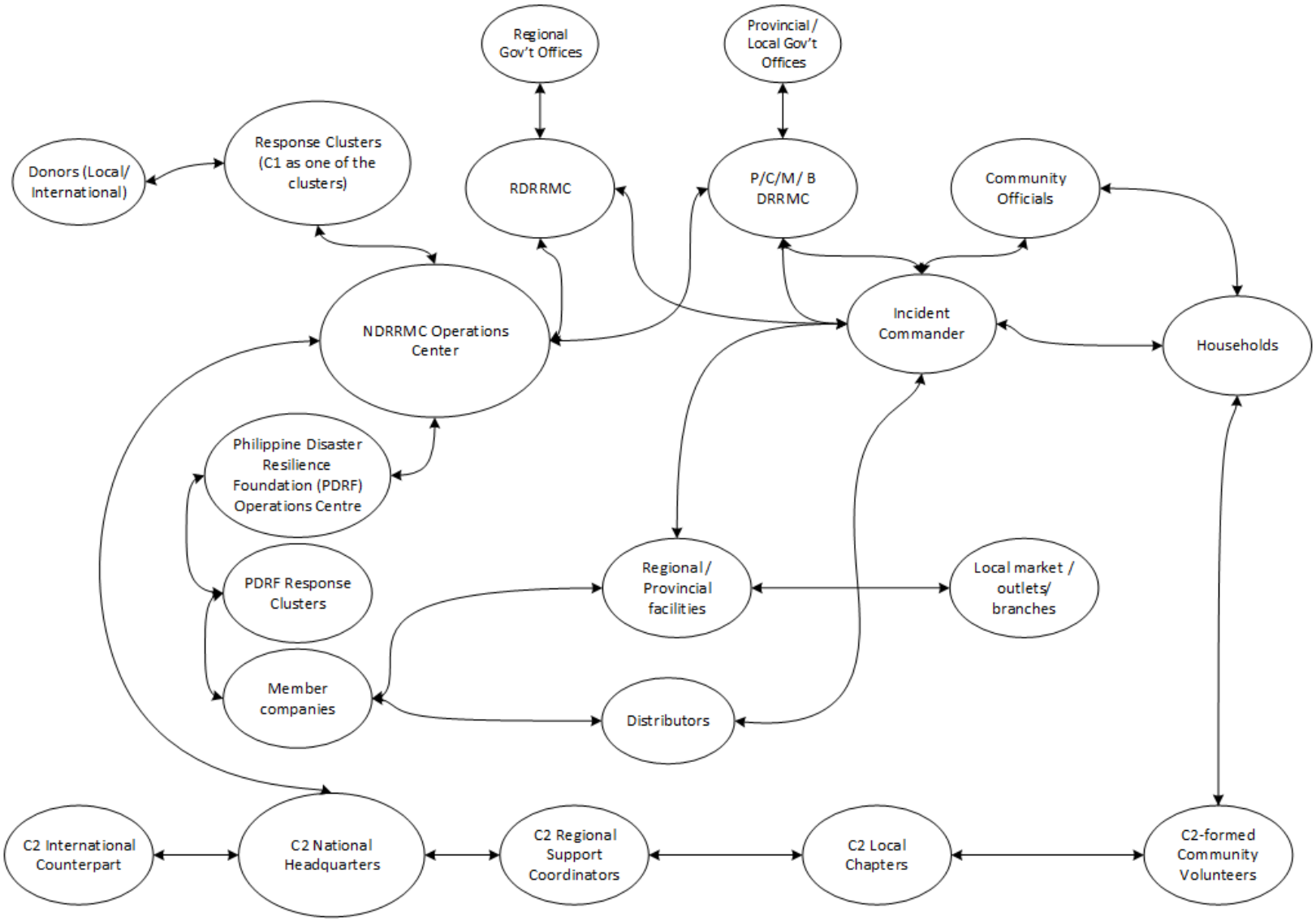

Figure 12. Information flows in Philippine DMSN

4.3. Analyse DMSNRES Considerations

4.3.1. Resilience Criteria

In analysing DMSNRES considerations, the study aims to develop a DMSNRES criterion by which cross-sector collaboration activities can be associated with. The structured literature review on supply network resilience has identified the top enablers of supply network resilience (Table 3). This study will adopt the finding of Scholten and Schilder (2015) that flexibility, visibility and velocity are the first-order enablers of resilience, and collaboration is an antecedent of these three. These constructs have been defined in the literature review section and respondents were asked to identify the DMSN capabilities which characterises each construct.

a) **Flexibility**

   Sourcing Redundancy – DMSNs rely on multiple sources that can provide the critical resources at the earliest possible time. Given the unpredictability factor in DMSNs, availability of back-up suppliers is of high importance.

b) Visibility

   Information Reliability – A DMSN is characterised by sporadic information flow. Hence, addressing this complexity will enable resilience for the DMSN. Factual information supported by available technology providing (big) data such as forecasts, damage estimates, population count, and other analytical information needed for informed decision-making

c) Velocity

   Responsiveness – Response is expected to arrive within 72 hours after a disaster event. It may also refer to faster return to normalcy.

The three aforementioned constructs mostly defined characteristics of an agile supply network. As Cozzolino et al. (2012) argued, the agile strategy applies mostly for immediate response, enabling fast reactive solutions. An additional resilience criterion to represent DMSN performance during proactive stages is deemed suitable as this study is not only limited to disaster response. Robustness has been identified in literature to pertain to proactive resilience (Välikangas, 2010; Durach et al., 2015) and will be used as an additional resilience criteria for DMSNs.

d) Robustness is the ability of the DMSN to resist change without changing its initial configuration (Wieland and Wallenburg, 2013). Disaster management experts describe robustness the ability of a community to sustain damages and is characterised by:

Capacity Building - Owing to the archipelagic geography of the Philippines, relief items may need to be transported by sea or air for inter-island relief operations which may require high costs or long lead times. This can be characterised by local availability of critical resources and skilled human resources.

4.3.2. Consequences for not practicing DMSNRES

Not putting high importance on DMSNRES will lead to repercussions in terms of in operational costs, economic damages, injuries and lives. Respondents were asked to recall scenarios where response was very challenging to manage. All of the respondents recalled the disarray they experienced during Typhoon Yolanda (Haiyan) in 2013. These consequences are summarised as follows:

1. There we no formalised triggers for national government intervention, hence the local communities felt the neglect by the delayed response of the national government
2. Unaligned knowledge between local government and the international humanitarian cluster system leading to disorganised operations on the ground
3. Proliferation of non-standardised needs assessment for targeted planning leading to multiple assessments done by each NGO, inducing indifference from the victims
4. Private sector and other NGOs preferred to work independently, bypassing LGUs and local DRRMCs, resulting to poor monitoring of the relief distribution.

4.3.3. Potential Future Scenario

6 years after Typhoon Yolanda, many learnings were applied especially on coordination and preparation measures. However, as with any operations, vulnerabilities still exist within the Philippine DMSN. Assessing the current DMSNRES against a potential future scenario will unravel resilience gaps which can be basis for resilience improvements in the Philippines. A future scenario identified from the Metropolitan manila Earthquake Impact Reduction Study (MMEIRS) is deemed by experts as a worst-case scenario for the Philippines. In particular, the Model 8 simulation, which is the potential rupture of the West Valley Fault (WVF) (Figure 13) is highlighted in the MMEIR study. This rupture is

estimated to produce a 7.2 magnitude earthquake, locally named by media outlets as “The Big One”. As the WVF traverses seven out of 16 cities within Metropolitan Manila, the scenario was considered the worst case in terms of damage. Furthermore, population density may contribute to the severity of the damage given that two of the world’s most densely populated city is found within Metropolitan Manila .Based on historical earthquake scenarios and census of population, the study was able to estimate the estimated casualties at 34,000 (JICA et al., 2004).

Three key scenarios are emphasised in MMEIRS, should the rupture of the WVF actualise.

1. Possible splitting of the region into 4 divisions: MM West, MM East, MM North and MM South; MM West isolated by fire. (Figure 13)
2. 1,200,000 people losing their residential homes and 34,000 people dead
3. 11% heavily damaged or collapsed out of 1000 mid-rise buildings; 2% heavily damages or collapsed out of 100 high-rise buildings

Figure 13. West Valley Fault traversing the whole Metropolitan Manila

4.4. Analyse Existing Cross-Sector Collaboration Activities

Types of collaboration activities were based on the study by Cao and Zhang, (2011). Each collaboration type was defined for the respondents. In turn, they identified characteristics of each in the lens of disaster management.

Collaborative communication and information sharing both pertains to sharing relevant information and message transmission. Hence, both types will henceforth be discussed in succeeding sections as **information sharing.** This type of collaboration is characterised by situational alerts before, during and after a disaster and formation of collaborative councils aimed at alignment and joint strategy development.

Goal congruence and incentive alignment both pertains to activities where collaborators are in either win-win situations (both experience benefits from the project) or risk-sharing situations. Both collaboration types will henceforth be discussed in succeeding sections as **incentive alignment.**

Decision Synchronisation refers to how collaborators in the supply network are able to collectively align their decisions. This may be characterised as collectively developing standard guides or contingency plans.

Joint Knowledge Creation refers to supply network actors engaging in collaborative learning activities. In a disaster context, this may include skills and process training and knowledge exchange workshops aimed at identifying best practices.

Resource Sharing refers to leveraging capabilities and assets of supply network collaborators. In disaster context, it is characterised by financial donations, sending of manpower to help on the ground or in relief warehouses, or offering the own organisation's products and services to address the needs of the DMSN.

4.5. DMSN Collaboration-Resilience Model

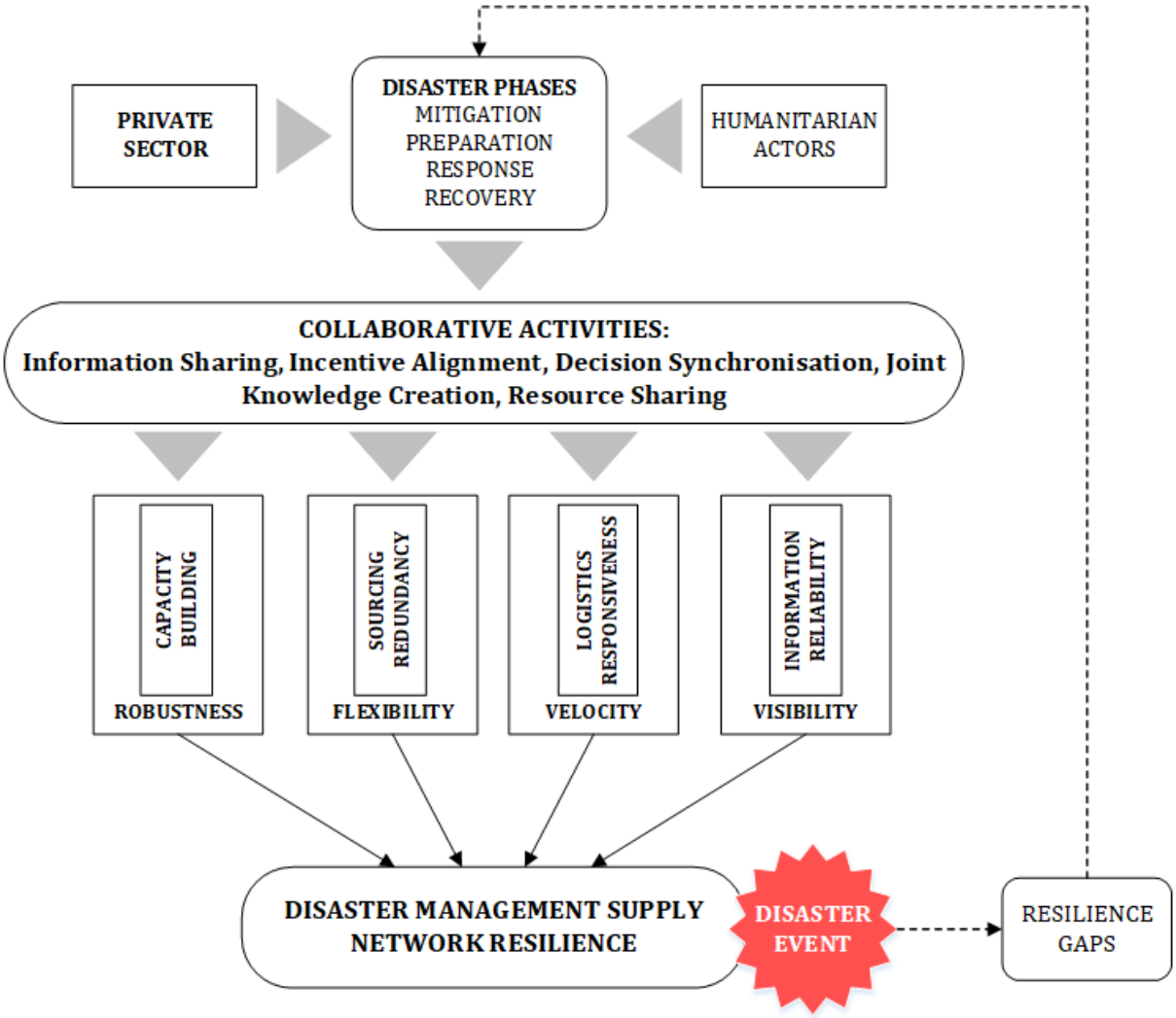

Figure 14. DMSN Collaboration-Resilience (COLRES) Relationship Model

Coming from the preceding analysis, a DMSN Collaboration-Resilience (COLRES) Relationship Model (Figure 14) has been developed with the goal of answering the main research question, *"How can resilience be built in DMSNs through cross-sector collaboration?"*. Application of the model involves two parts:

(1) identification of collaboration activities between the private sector and humanitarian actors which translates to several outcomes for the DMSN which can be related to the resilience criteria and eventually building DMSNRES; and

(2) assessing the DMSN against a disaster event where resilience gaps are revealed and can be inputted as new opportunities for collaboration. As manifested in literature, resilience building is a continuous process rather than a one-time task (Tukamuhabwa et al., 2015). The DMSN COLRES Model reflects that finding.

5. Case Study Findings

The DMSN COLRES Model as an analytical tool is applied to the Philippine DMSN. Respondents were asked to identify specific cross-sector collaboration activities exhibiting private sector involvement in DMSN were identified in each disaster management phase – mitigation, preparation, response and recovery. Additional collaboration activities were identified in published articles and reports (ILO, 2015; PDRF, 2019). Each activity was classified according to the collaboration types defined in the DMSN COLRES Model. Direct outcomes of each collaboration activity were at the same time identified with the respondents. Each outcome was classified into a generalised outcome based on DMSN capabilities it was most related to (Capacity building, sourcing redundancy, information reliability, and logistics responsiveness). These DMSN capabilities were finally linked to the resilience criteria best characterising the benefit of the activity. The results of this analysis are presented in Table 8.

Table 8 – Collaboration-Resilience Relationship Analysis

Collaboration Types: DS- Demand Synchronisation; JKC – Joint Knowledge Creation; IA – Incentive Alignment; IS – Information Sharing; RS- Resource Sharing

Disaster management phase	Collaboration Activity	Collaboration Outcome	Collaboration Type	Generalised outcome	Resilience Criteria
Mitigation	Co-development of MSME guide to disaster response by DTI and PCCI	Standardised preparedness measures	DS	Capacity Building	Robustness
	Development of "*Katatagan* in a Box" - BCP Mobile App	Wider access to BCP	DS	Capacity Building	Robustness
	Updated National Energy Contingency Plan	Less disruptions in energy SC	DS	Capacity Building	Robustness
	Development of Resiliency Compliance Plan	Less disruptions in energy SC	DS	Capacity Building	Robustness
	Knowledge exchange: CBi private sector networks	Improved disaster management practices	JKC	Capacity Building	Robustness
	Commercial supply chain resilience workshops	Reduction of vulnerabilities on commercial operations	JKC	Capacity Building	Robustness
	Public service resilience workshops	Reduction of vulnerabilities on government operations	JKC	Capacity Building	Robustness
	Community-based disaster risk reduction and management	Reduction of vulnerabilities in the community	DS	Capacity Building	Robustness
Preparation	Project AGOS: improving disaster communications systems of LGUs	More reliable communication mechanisms at local level	IA	Info Reliability	Visibility
	A-PAD PH: Multi-sectoral platform for coordination for pooling of efforts at regional level	Increased local capacity within the region	IS	Capacity Building	Robustness
	C1 and PDRF memorandum of agreement for disaster response	Back-up sources augmenting the capacity of the government	IA	Redundancy	Flexibility
	Collaborative platform using mobile and web technologies and social media initiated by an online news company	Households able to broadcast real-time situations	IS	Responsiveness	Velocity
	2019 National Summit on Strengthening Disaster Resilience for for MSMEs	Execution of best practices	JKC	Capacity Building	Robustness

Table 8 – (cont) Collaboration-Resilience Relationship Analysis

Disaster management phase	Collaboration Activity	Collaboration Outcome	**Collaboration Type**	Generalised outcome	Resilience Criteria
Preparation	PDRF participation in local government DRRMC	Private sector inclusion in disaster preparedness especially in cities with CBDs	IS	Capacity Building	Robustness
	C1 procurement for family food packs	Push-button activation of production line for family food packs components; in pre-positioned warehouses	IA	Responsiveness	Velocity
	C2 procurement of evacuation kits	Ensure quality of kits procured, enable stockpiling in prepositoned warehouses before the disaster event	IA	Responsiveness	Velocity
	C2 local procurement on disaster site's local market	Co-location sourcing	IA	Responsiveness	Velocity
	Situational advisories to PDRF member companies for internal preparedness	Timely activation of disaster preparedness plans for the welfare of the employees & company	IS	Responsiveness	Velocity
	Situational advisories to PDRF member companies for response	Faster response to needs on the ground	IS	Responsiveness	Velocity
	Participatory 3D mapping - private sector and *barangay*	Reduction of vulnerabilities within the community; faster recovery of community means faster recovery of the company	IA	Capacity Building	Robustness
	Company employee trainings on preparedness	Reduce vulnerabilities on household level	JKC	Capacity Building	Robustness
Response	Creation of clusters within PDRF, aligned with NDRRMC clusters and UN clusters	Faster coordination and decision making and relevant information sharing	IS	Responsiveness	Velocity
	PDRF EOC: the first-ever private sector-led EOC	Quality in data analytics supporting fact-based decision making	IA	Info Reliability	Visibility
	Post-disaster coordination meetings in NDRRMC	Alignment of action plans resulting to reduced redundancy of efforts	IS	Info Reliability	Visibility

Table 8 – (cont) Collaboration-Resilience Relationship Analysis

Disaster management phase	Collaboration Activity	Collaboration Outcome	Collaboration Type	Generalised outcome	Resilience Criteria
Response	Revival of the Philippine Cash Working Group	Alignment of action plans resulting to reduced redundancy of efforts	IS	Info Reliability	Visibility
	Financial companies pool funds for humanitarian orgs	Flexibility in the kinds of interventions that can be bought/done	IA	Redundancy	Flexibility
	An energy company provided generator sets, floodlights and heavy equipment for search and rescue; Fast food Chain A and Fast food Chain B supplied food packs for rescuers; Pilipinas Petroleum company provides fuel for generator sets; A real estate development company's provision of structural engineers;	Multiple sources of critical items for response	RS	Redundancy	Flexibility
	Damage assessment equipment such as helicopters from private companies	Multiple sources of critical items for response	RS	Info Reliability	Visibility
	Emergency telecommunications resources from telecommunications companies	Enable transfer of information from the ground	RS	Info Reliability	Visibility
	Trucks owned by a logistics company deliver C1 family food packs Typhoon Ompong (Mangkhut) victims	Faster delivery of relief items	RS	Responsiveness	Velocity
	Mall opened for temporary shelter; elevated parking spaces made available for flood avoidance	Make-shift evacuation shelters made available	RS	Redundancy	Flexibility
	A telecommunications company and anti-hunger NGO deliver food packs	Multiple sources of critical items for response	RS	Redundancy	Flexibility
	A telecommunications company deploys instant network units in Batanes and Cagayan	Enable transfer of information from the ground	RS	Info Reliability	Visibility

Table 8 – (cont) Collaboration-Resilience Relationship Analysis

Disaster management phase	Collaboration Activity	Collaboration Outcome	Collaboration Type	Generalised outcome	Resilience Criteria
Response	A mall opened for assistance to nearby residential communities by providing temporary evacuation with in-house clinics	Faster evacuation and urgent medical attention	RS	Responsiveness	Velocity
	Mall sent mobile clinic to Villamor Airbase during Typhoon Haiyan, attending to victims airlifted from Tacloban to Manila	Faster support for medical needs, no need to travel to hospital	RS	Responsiveness	Velocity
	Donations from several private stakeholders	Multiple sources of critical items for response	RS	Redundancy	Flexibility
	Needs assessment participation - manpower	Faster accomplishment of needs assessment, more details gathered	RS	Info Reliability	Visibility
	C2 partnership with tech company for rapid geological assessment through drones	Rapid assessment of far-flung areas which cannot be easily reached	RS	Responsiveness	Velocity
Recovery	NGOs send money to PDRF to fund rebuilding projects rather than work through more bureaucratic structure	Faster execution of plans; skip bureaucracy	IA	Responsiveness	Velocity
	Electric company's restoration of power in Batanes - sending of skilled technicians	Support the incapacity of the local area to return to normalcy	RS	Redundancy	Flexibility
	Electric company's restoration of power in Batanes - sending of skilled technicians	Local electric cooperative technicians indirectly learning new skills and adapting new ways to work from Meralco's team of engineers	JKC	Capacity Building	Robustness
	Joint effort to replant mangroves in Roxas City - sending manpower	Building back better for the community	RS	Capacity Building	Robustness
	Pooling of funds for new relocation facility for the victims of Typhoon Yolanda (Haiyan)	Building back better for the community	IA	Capacity Building	Robustness
	Early recovery assistance on women's livelihood recovery in Itogon, Benguet	Building back better for the community	IS	Capacity Building	Robustness

Table 89 – (cont) Collaboration-Resilience Relationship Analysis

Disaster management phase	Collaboration Activity	Collaboration Outcome	Collaboration Type	Generalised outcome	Resilience Criteria
Recovery	Consultation workshop on the recovery and rehabilitation from the M6.1 earthquake in Central Luzon	Building back better for the community	JKS	Capacity Building	Robustness
	C2 & a private company collaborating to apply recovery strategies in the workplace in 2016	Reduced vulnerabilities in the workplace	JKS	Capacity Building	Robustness

5.1. Cross-sectoral Collaboration and Resilience

The results were plotted in graphs which shows the relationships between the collaboration types and the resilience criteria. However, analysis of the relationship of the disaster management phase with both collaboration types and resilience criteria can provide new insights as well. Phase and collaboration relationships were plotted in Figure 15.

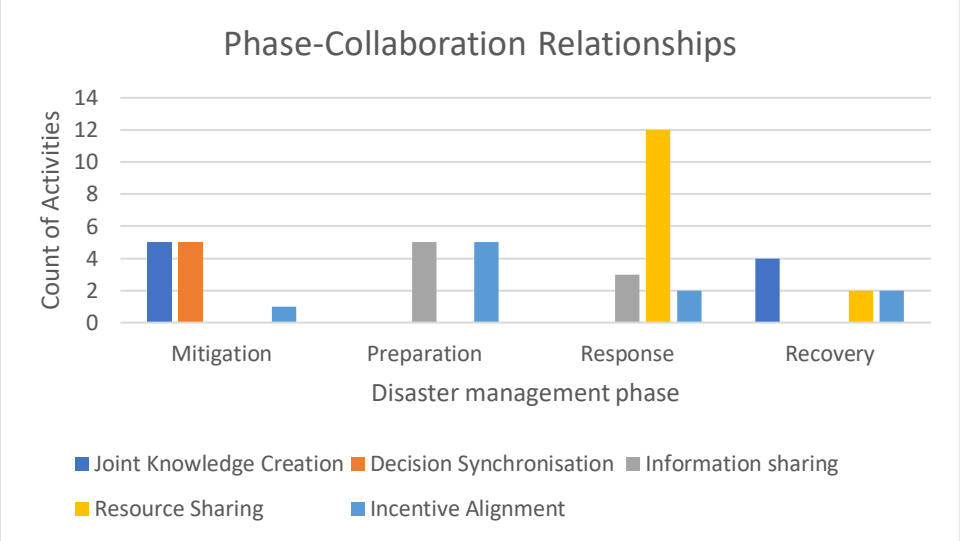

Figure 15. Collaboration activities in difference disaster management phases

In mitigation phase, most collaboration activities were on decision synchronisation (DS) and joint knowledge creation (JKC). Activities under DS are characterised by co-development of standards and contingency plans which relevant organisations may use to prepare for disasters. Workshops are usually the activities under JKC in the mitigation phase, characterised by supply network resilience trainings and public service continuity trainings. Within the preparation phase, incentive alignment (IA) and information sharing (IS) is mostly observed. This is characterised by agreements such as procurement partnerships and regular coordination meetings between organisations in different sectors.

Within the response phase, resource sharing (RS) is noticeably common. Private companies provide their core resources such as generator sets from electric companies, fuel from an oil and gas company, food packs from chains of restaurants, and trucks for relief items delivery coming from third-party logistics providers. All these resource provisions from the private sector were made possible by effective coordinated activities through the umbrella organisation, PDRF and its emergency operations centre. Under the

recovery stage, JKC is common through livelihood trainings for the community in collaboration with private enterprises and the LGU. Consultation workshops between the private sector, LGU and NGOs for joint development of recovery strategies are also held.

The kinds of resilience criteria built on by collaboration activities conducted in different disaster phases are shown in Figure 16. It was found that especially in the mitigation phase, collaboration activities were mostly for the purpose of capacity building and therefore influence mostly on the resilience criteria of robustness. The preparation phase holds a good mix of initiatives to increase DMSNRES through velocity and robustness. These include activities to enable fast response such as pre-positioning, co-location sourcing. Many collaboration activities that address visibility, flexibility and velocity were noticeably related to disaster response. Collaboration activities inducing robustness were found within the recovery phase as main objective within this phase is to "build back better" by not only restoring communities back to normalcy, but also further reduce vulnerabilities.

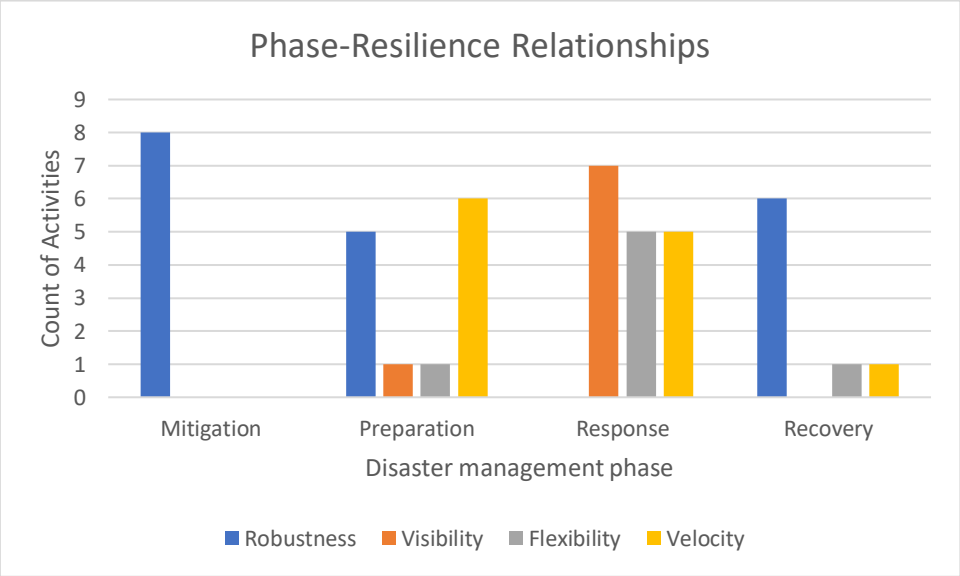

Figure 16. Phase-Resilience Relationships

Finally, to relate the collaboration activities to resilience building, the results are plotted in Figure 17. Evidently, a collaboration type does not exclusively influence only one resilience criteria.

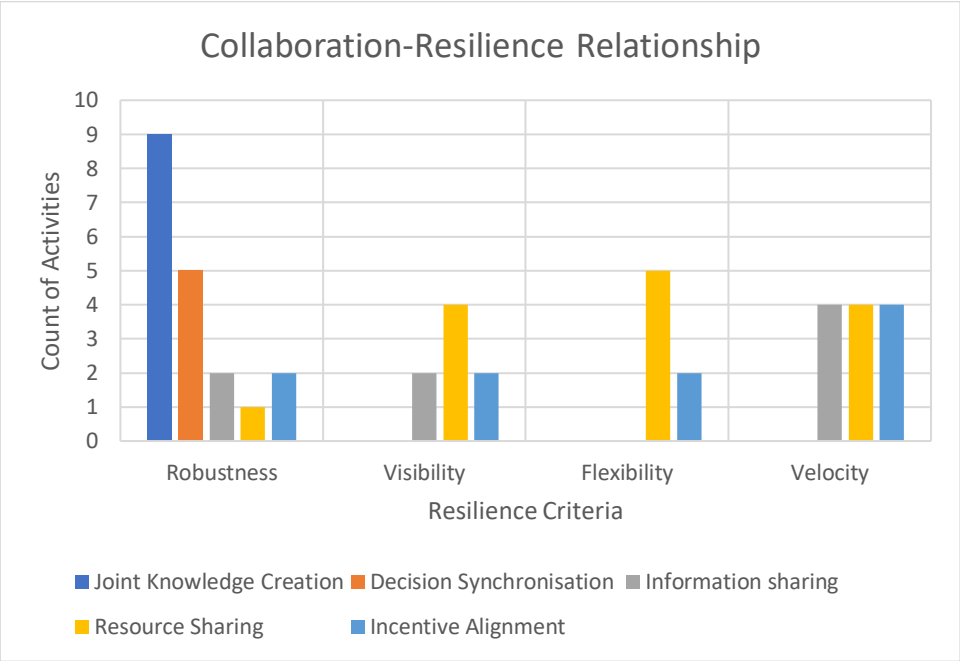

Figure 17. Collaboration-Resilience Relationship

JKC and DS are found to influence robustness the most. JKC and DS are characterised by capacity building through knowledge exchanges in skills training, standardisation of processes, and updating of contingency plans to reduce overall disruption within the DMSN. Outcomes of these activities help build capacity for local communities, organisations, and government agencies. With better capacities in terms of skills, resources or processes, these entities are able to sustain themselves for longer periods of time. Hence, unpredictability in demand surges as well as short lead times within the DMSN are minimised.

RS, IS and IA influence visibility. RS enables visibility particularly when private companies are able to share critical resources such as portable telecommunication devices, and damage assessment equipment such as helicopters to be able to quickly gather information on the disaster site. IS activities involve formation of collaboration platforms for information flow to share timely updates and align on priorities for the DMSN. Visibility within the DMSN minimises unpredictability in situational status on the ground and allows appropriate interventions to be sent where it is needed the most.

Flexibility is highly influenced by resource sharing characterised by multiple companies offering manpower, their own products or services ranging from food, drinks, telecommunications and logistics equipment, infrastructure expertise, finance and medical services. Resource sharing augments the government or NGO's typical capacity to attend to the needs of disaster victims. Multiple private companies located in multiple regions, willing to supply their company assets create redundancy within the DMSN and addresses the unpredictability in terms of where the disaster might occur.

Velocity is influenced by a mix of RS, IA, and IS. Building from RS which highly influences flexibility, the ability to find alternative suppliers from the multiple private companies offering their services, positively influences velocity as well since sources for supplies are identified at a faster pace. IA also influence actors to respond quickly since acting upon the matter leads to either benefits shared between the collaborators. An example is a supplier engaged in a pre-agreed procurement contract with the government or NGO. Having the capability to deliver as soon as possible returns profits for their organisation. IS allows DMSN actors to respond faster since these activities lead to clarity of information and hence clarity on the forward actions the needed to attend to within DMSNs. Collectively, these activities induce responsiveness between the collaborators and addresses the complexity of a DMSN on short lead time requirements. Faster response means time saved and eventually, lives saved from further danger.

5.2. Evaluation of DMSNRES against Future Scenario

The future scenario identified from MMEIRS is deemed by experts as a worst-case scenario for the Philippines (Section 4.3.3). To recall, three key scenarios are emphasised in MMEIRS, should the rupture of the WVF actualise.

1. Possible splitting of the region into 4 divisions: MM West, MM East, MM North and MM South (Figure 13); MM West isolated by fire
2. 1,200,000 people losing their residential homes and 34,000 people dead
3. 11% heavily damaged or collapsed out of 1000 mid-rise buildings; 2% heavily damages or collapsed out of 100 high-rise buildings

This section will identify resilience gaps against this future scenario for further opportunities for collaboration; illustrating how resilience and cross-sector collaboration are positioned in a continuous improvement cycle.

5.2.1. Robustness - Capacity Building

Resilience Gap:

- The capacities within each of the four MM divisions may not have been assessed yet.

Collaboration opportunity:

- Cross-sector collaborations during mitigation phase targeting to improve "local" capacity of each MM division.
- Trainings on first aid and evacuation procedures for households, public sector, private sectors and NGOs contained within each division to reduce immediate dependence on response teams.

5.2.2. Flexibility - Sourcing Redundancy

Resilience Gap:

- Uncertainty of the extent of actual damage in "The Big One" would mean additional complexity to the DMSN in terms of where the critical resources can be acquired.
- The national hubs of both C1 and C2 are both located in Metropolitan Manila and may each be isolated to some MM West and MM North, respectively.

Collaboration opportunity:

- Identification of multiple potential suppliers of critical resources to serve each division
- Collaboration with the private sector can be initiated to identify private sector assets which can be found within each division.
- Pre-positioning of resources within each division

5.2.3. Visibility - Information Reliability

Resilience Gap:

- In the context of "The Big One", reports from ground zero will be received in the separate emergency operations centres of PDRF, C2 and NDRRMC
- Deterministic maps instead of probabilistic maps still being used in disaster prevention and development planning.

Collaboration opportunity:

- Develop alignment mechanisms to triangulate and validate each other's information from the ground and quickly agree on forward interventions as needed on the disaster site
- Collaboration with UP NOAH on installation of sensors and usage of probabilistic maps; enabling analysis of real-time data to provide prompt warnings and emphasise the urgency of evacuating communities at the earliest possible time (LLCAD, 2017)

5.2.4. Velocity - Responsiveness

Resilience Gap:

- Challenge in resources movement due to massive damage in infrastructure

Collaboration opportunity:

- Collaborating with organisations with assets for airlifting materials may be of relevance to the scenario
- Mapping of first responders coming from nearby regions especially on the MM North, MM South and MM East which can all be accessed from other parts of the Luzon island (Figure 13).

6. Discussion

Forty-six collaboration activities were identified from the case study. Within each disaster management phase, various collaborative types are present. Eleven collaboration activities were identified in the disaster mitigation phase composed of joint knowledge creation (JKC) and decision synchronisation (DS) . Cross-sector collaboration activities within this phase are typically knowledge exchanges between private, public and NGO sectors. Business continuity workshops are found to not only be applicable to commercial supply networks, but also can be adapted for public service continuity and disaster management supply networks.

Ten out of 46 collaboration activities were identified in the disaster preparation phase. In the preparation phase, activities for response readiness are done. This is supported by the results which shows that 6 out of the 10 collaboration activities within preparation phase influence responsiveness. Results show that cross-sector collaboration in this phase involves incentive alignment (IA) and information sharing (IS). IA activities such

as pre-agreed procurement contracts enable push-button activation of production lines for relief items, ultimately enabling quick response should a disaster occur.

High amount of collaboration activities found in the response phase echoes literature where it is in the response phase where most private sector involvement are observed (Balcik et al., 2010; Wang et al., 2016). However, most of the literature show limited private sector roles such as procurement partners and provider of short-term support (Nurmala et al., 2017). The results of this dissertation show that private sector involvement within disaster response phase goes beyond mere logistics support as commitments to lend company-owned assets from many industries are being practiced in the Philippine DMSN. These assets range from telecommunications equipment, energy generating assets such as generator sets from electric companies, medical assistance, to infrastructure assets. Especially for a developing country like the Philippines, privatisation of critical resources and utilities is common. Hence, the involvement of the private sector in disaster response is well appreciated to augment government capacity.

It is important to note that an effective coordinating body drives these resource sharing (RS) efforts. PDRF was able to establish a network for RS which allows businesses from different industries to pool their core resources together and share the risks by reducing each of their operational costs. This builds on the findings from Izumi and Shaw (2014) on the necessity to establish a coordinating body in order to have a platform of multi-stakeholders for discussions, information dissemination and learnings.

The identification of cross-sector collaboration activities within the DMSN and throughout the four disaster management phases, debunks the common perception in literature that involvement of the private sector is only limited to ad-hoc contributions such as financial, product or logistics support (Nurmala et al., 2017) during disaster response. While most collaboration activities are still identified within the disaster response phase, cross-sector activities found in mitigation and preparedness phase illustrates that private sectors are proactively involved in disaster management operations.

Collaboration activities influencing robustness were found to be JKC and DS. Within the mitigation phase, robustness is built. This finding is aligned with literature on robustness as a proactive resilience building construct (Välikangas, 2010; Durach et al., 2015).

Knowledge exchanges, co-development of standard disaster preparedness and response processes, as well as strengthening of contingency plans to reduce vulnerability in the supply chain of critical resources are examples of activities that help build capacity and eventually lead to supply network robustness.

Collaboration activities which increase visibility are usually found in response phase. It is acknowledged in the literature that sporadic information flow is one of the most common complexities in DMSNs (Olaogbebikan and Oloruntoba, 2017), hindering effective relief operations. The importance of information sharing enabled by the formation of coordinating councils on the ground and on higher level of management is emphasised to increase visibility within DMSNs. Beyond information sharing activities, resource sharing of communication equipment are found to be of critical importance (Figure 17). This study finds that the availability of telecommunications mechanisms is a critical precursor for effective information sharing.

Building flexibility through resource sharing is commendable within the Philippine DMSN given the high involvement of companies in this collaboration activity. Moreover, findings illustrate that resource sharing is not limited to short-term support since private companies which willingly lend their assets to the public sector comes from a wide range of industries. Through cross-sector collaboration, multiple sources of funds enable pooling of financial donations which allow them to adapt the interventions they will provide according to the needs of the beneficiaries, enabling flexibility.

Velocity is highly present in disaster response phase. This finding reiterates the need for agile strategy within the immediate response phase as manifested by (Oloruntoba and Gray, 2006; Scholten et al., 2010; Cozzolino et al., 2012). Velocity is highly influenced by three collaboration activities – incentive alignment, information sharing and resource sharing that influences responsiveness.

The evaluation of DMSNRES against a future scenario reveals resilience gaps which can be used to identify more cross-sector collaboration opportunities and reiterates the findings from Tukamuhabwa et al (2015) that resilience building is not a linear process, but rather a continuous one.

From literature, a DMSN is characterised by complexities identified in Table 2. Unpredictability is identified as the top issue for DMSNs. Short lead times, high stakes

involved, and sporadic information flow also continue to hinder disaster management actors in effectively managing DMOs. This study finds that cross-sector collaboration builds resilience through the constructs of robustness, flexibility, velocity and visibility. and address complexities identified within the DMSNs. Robustness in skills, resources or processes enable communities, organisations, government agencies to sustain damage for longer periods of time resulting to reduced unpredictability in demand surges in a DMSN. Visibility within the DMSN minimises unpredictability in situational status on the ground and enables the right resources to be delivered to the right beneficiaries at the right time. Multiple private companies located in multiple locations provide their assets and create flexibility within the DMSN; addressing the unpredictability in terms of the location of disaster occurrence. Velocity in response addresses the urgency of the delivery of resources, eventually leading to time saved and lives saved from further danger.

7. Conclusion

With the aim to answer the main research question *"How can resilience be built within DMSN through cross-sector collaborations?",* this dissertation analysed relationships between cross-collaboration and disaster management supply network resilience (DMSNRES) through a theoretical model **(RO1)** developed from an exploratory case study. This model is applied to an empirical study where cross-sector collaboration activities were identified within each disaster management phase **(RO2)** and contributes new academic knowledge that private sector involvement is not only limited to short-term ad-hoc interventions. Causal analysis between cross-sector collaboration activities and DMSNRES criteria was done by analysing specific outcomes of existing collaboration activities **(RO3)**.

Cross-sector collaboration builds resilience in DMSNs through capacity building, sourcing redundancy, information reliability, and logistics responsiveness. Cross-sectoral knowledge exchanges, co-development of standards and contingency plans can help build capacity. Development of a platform for sharing resources from different business industries not only creates flexibility in the DMSN, but also can potentially reduce operational costs of the companies as compared to doing separate corporate social

responsibility (CSR) activities. Information reliability can be achieved through development of cross-sectoral coordinating bodies, investment in technological tools leading to improved forecasts, as well as ensuring the availability of emergency telecommunications equipment by establishing partnerships with private telecommunication companies. Finally, logistics responsiveness can be achieved through partnerships with resource providers from multiple locations as well as timely information sharing.

This study has identified potential areas where the private sector, the government, and humanitarian agencies can establish stronger links. This study shows that the private sector is able to go beyond these existing short-term partnerships by participating in collaboration activities within each disaster management phase in order to build resilience in disaster management supply networks. At present, most of the private sector involvement in DMSN, while becoming more common, has not yet been institutionalised in any national response plans. The is a potential for the government to leverage on the strengths of the private sector without losing core competence and authority to drive disaster management in the Philippines.

7.1. Limitations of the Study

As with any other research, this study is bounded within limitations. The theoretical model has been applied to one case study, which is the Philippine DMSN. Only three organisations were interviewed in the case study; while they all representative of different key sectors involved in DMSNs, findings may not exhaustively reflect all existing collaboration activities. Relating the collaboration activities to their outcomes and eventually to the resilience criteria, although done by experts within the organisations, may still involve misjudgements due to subjective understanding of the concepts within this study.

7.2. Contribution to Academic Knowledge

This dissertation addressed the research gaps on (i) scarce literature focusing on collaboration as an antecedent of resilience; (ii) less explored domain of supply network resilience in disaster management; (iii) literature on private sector involvement in DMSNs limited within short-term support.

1. The DMSN Collaboration-Resilience Exploratory Framework (Figure 9) is a framework that can be used to explore and contextualise collaboration and resilience considerations within DMSNs. It can be used as a preliminary guide for creating contextualised collaboration-resilience relationship models for organisations.
2. The DMSN Collaboration-Resilience Relationship Model (Figure 14) is a novel method for analysing cross-sector collaboration activities from a resilience perspective. The model can be used by organisations within the humanitarian or private sector to identify existing collaboration activities and understand its influence to improving resilience.

7.3. Implications for Further Research

Future work could be done by applying the model to more cases such as other countries' DMSNs, or to more specific contexts such as inter-organisational collaborations rather than big sectors. A more detailed assessment method against a future disaster will prove relevance for the model in providing practical insights on how resilience can be built in DMSNs.

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Appendix

General organisation overview:	***Learnings from Typhoon Yolanda***
1. Mandate of the organisation 2. Mission and vision of the organisation 3. Stakeholders / current network 4. Internal organisation and responsibilities of sub-units	1. How did the agency respond to Typhoon Yolanda? 2. What changed since 2013 Typhoon Yolanda? 3. Were there new practices in place?
Disaster management process:	***Identification of cross-sector collaboration activities within each disaster management phase:***
1. Current process of disaster response and how the team prepares for it 2. How the strategies for disaster response influence other disaster management phases (preparation, mitigation, recovery) 3. Process for pre-positioning of relief items 4. Presence of regional facilities 5. Top products identified during rapid needs assessment 6. The structure of the information flow from ground-up 7. Sourcing strategies with procurement, donations 8. Criteria for accepted donations 9. KPIs measured, basis of KPI targets	1. Mitigation 2. Preparation 3. Response 4. Recovery