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Natural disaster contingencies and building supply chain resilience with integration

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ABSTRACT

In recent decades natural disasters have caused major problems for supply chain managers. For example, the Tohoku earthquake and tsunami severely disrupted the automotive industry in 2011, and tropical cyclone Debbie significantly affected the flow of goods and services in Australia's agricultural and coal industries in 2017. As a result of such events, building supply chain resilience (SCRES) against natural disasters has emerged as an important issue for both scholars and practitioners.

The existing operations and supply chain management (OSCM) research has uncovered 19 different models for SCRES. However, none of the models has been widely accepted in academia, and this has made it difficult for researchers to compare findings and test the relationships that may exist between SCRES and other contingencies.

The present study advances theory and practice by examining SCRES as a four-stage process and investigates the contribution of supply chain integration (SCI) to SCRES building in relation to natural disasters. In this regard, the study aims to:

Objective 1: determine how SCRES building works in practice and expand on the existing SCRES models

Objective 2: identify and describe performance indicators of successful SCRES building as a process and provide guidance for the development of a single, unique SCRES measure

Objective 3: clarify how SCI is utilised to support successful SCRES building and create a model that captures SCRES building, measurement insights and SCI that supports SCRES for future research.

To recognise and capture the complexities associated with SCRES building in conjunction with SCI, the study examines SCI orientation and type. The study utilises a multiple case study design by examining 13 different natural disasters and 22 different SCs. Each case generates insights from interviews conducted with practitioners and is enriched with supplementary secondary data. The study is also informed by structural contingency theory.

The study concludes that the existing four-stage SCRES model extant in the literature needs to be expanded with one new stage and two additional operations that take place during SCRES building. In addition, the study identifies three main performance indicators of successful SCRES building that provide valuable measurement insights.

In terms of SCI, the study confirms the supportive nature of Operational SCI to SCRES and clarifies the relationship between Informational and Relational SCI in relation to SCRES. The government is recognised as an important stakeholder and trust is inductively captured as valuable for SCRES building.

The study contributes to the OSCM literature in terms of understanding SCRES as a process and provides strong guidance for unified SCRES measure development. It identifies SCI as an important practice for SCRES building and details a foundation for testing in future quantitative research. Significant practical implications include guidance for practitioners in terms of improving the SCRES building process and its performance, as well as guidance for SCRES measurement and improvement of SCI with the purpose of SCRES building.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

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Date: …06/11/2019……

Publications during enrolment

A. Drozdibob, A. Sohal, S. Fayezi, C. Nyland 'How is supply chain integration altered to support supply chain resilience building?', 17th ANZAM Operations, Supply Chain and Services Management Symposium, Melbourne, VIC, Australia, July 2019.

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CONTENTS

List of Abbreviations

AAP	Australian Associated Press
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AIDR	Australian Institute for Disaster Resilience
ANZAM	Australian and New Zealand Academy of Management
AU	Australia
AUD	Australian
BOM	Bureau of Meteorology
CIA	Central Intelligence Agency
CM	Crisis management
CRED	Centre for Research on the Epidemiology of Disasters
CRS	Congressional Research Service
DAO	Directly affected organisation
DIDRC	Department of Infrastructure, Regional Development and Cities
DILGP	Department of Infrastructure, Local Government and Planning
DM	Disaster management
EBIT	Earnings Before Tax and Interest
ENS	Environment News Service
EUROMA	European Operations Management Association
FEMA	Federal Emergency Management Agency
FMG	Fortescue Metals Group
GDP	Gross domestic products
GovHK	Government of Hong Kong
GOVPH	The Philippine Government
IAG	Insurance Australia Group
ICA	Insurance Council Australia
IGEM	Inspector-General Emergency Management
IL	Illinois
JMA	Japan Meteorological Agency
LM	Logistic management
NGO	Non-Government organisation
NHC	National Hurricane Centre
NOAA	National Oceanic and Atmospheric Administration
NSW	New South Wales
OSCM	Operations and supply chain management
QGSO	Queensland Government Statistician's Office
QLD	Queensland
RBA	Reserve Bank of Australia
RM	Risk management
RQ	Research question

SA	South Australia
SC	Supply chain
SCI	Supply chain integration
SCLAA	Supply Chain and Logistics Association of Australia
SCM	Supply chain management
SCRES	Supply chain resilience
SEMC	State Emergency Management Committee
TC	Tropical cyclone
T&L	Transport and logistic
USA	United States of America
UNISDR	United Nations Office for Disaster Risk Reduction
VIC	Victoria
WA	Western Australia
WEF	World Economic Forum

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CHAPTER 1: INTRODUCTION

1.1 Background and Rationale of the Study

Globalisation, technological advancements and an increase in the world's population have provided many opportunities and challenges in modern business. Today's businesses operate as part of global supply chains (SCs). They source materials and other resources from multiple locations, utilise various transport types and carriers, manufacture at several sites, and distribute and sell globally. Consequently, today's SCs are more complex than ever before, operating across many locations involving stakeholders from around the world.

However, globalisation and technological developments are not the only attributes of the modern world. Researchers have identified a significant increase in the frequency and severity of natural disasters over the last four decades (Boin & Lagadec, 2000; Eshghi & Larson, 2008; IFRC, 2016; Smet, Lagadec, & Leysen, 2012), although some recent reports suggest a decrease in the number of natural disasters occurring globally (CRED, 2019). While there is some discrepancy over these trends, the latest research agrees that 21st-century natural disasters are less predictable and more difficult to manage due to cascading events and prolonged effect (Corey & Deitch, 2011; Lawther, 2016). In the United States (US) alone, damage caused by natural disasters has increased five times over the past two decades (UNISDR, 2015). On average over last two decades, in Australia, natural disasters have cost the national economy AUD18.2 billion annually, which represents 1.2% of Australia's gross domestic products (GDP) (Handmer, Ladds, & Magee, 2018; Insurance Australia Group [IAG], 2017). This cost is expected to double by 2040 (Handmer et al., 2018; IAG, 2017; Ronnenberg, O'Sullivan, & Hartzer, 2017), with global annual losses from natural disasters set to reach AUD568 billion for infrastructure investments alone (Reserve Bank of Australia [RBA], 2019 [exchange rate]; UNISDR, 2015).

Thus, while globalisation has enabled businesses to access new markets, it also increases their exposure to being affected by unpredictable 21st-century natural disasters—directly at new locations, or indirectly through buyers and suppliers. For example, the Tohoku earthquake and tsunami severely disrupted multiple automotive SCs in 2011 (Matsuo, 2015) with estimated financial losses of AUD282.5 billion (RBA, 2019 [2015 exchange rate]), making it the costliest natural disaster recorded to date (Wallemacq & House, 2018). Car

manufacturer Toyota was indirectly affected by its suppliers being directly affected (Matsuo, 2015). In Australia in 2017, tropical cyclone Debbie disrupted the agricultural and coal industries nationally, amounting to billions of dollars of damage (IGEM, 2017). As a result of these and similar cases, the notion of supply chain resilience (SCRES) against natural disasters has emerged as an important issue for both scholars and practitioners (Van der Vegt, Essens, Wahlstrom, & George, 2015). SCRES is defined as a SC's ability to prepare for the effects of a natural disaster, respond to those effects and successfully recover from them (Ponomarov & Holcomb, 2009). Learnings from previous experiences with natural disasters continuously improve a SC's resilience (Scholten, Scott, & Fynes, 2014).

To address this issue, scholars in operations and supply chain management (OSCM) have developed 19 different models for SCRES building (Burnard & Bhamra, 2011; Kamalahmadi & Parast, 2016). However, none are widely accepted in academia, which has hindered the establishment of a single unique measure of SCRES. Also, researchers do not agree on whether SCRES is a process or a feature of SCs (Bhamra, Dani, & Burnard, 2011). All 19 models developed in the literature suggest SCRES is a process, as different stages in operations are recognised over time in relation to disruption proximity. However, researchers do not agree on the performance indicators of this process, and offer different measures of SCRES. Thus, researchers started measuring resilience using various indicators (Brandon-Jones, Squire, Autry, & Petersen, 2014; Pettit, Croxton, & Fiksel, 2013). This has limited the ability to compare research results and has also limited quantitative studies being conducted to test the various relationships between SCRES and other possibly relevant factors. Consequently, an examination of existing SCRES building models is required in relation to SCRES understandings in practice. The purpose of this improved understanding is to select a single SCRES building model for future studies. Further, an examination of the existing performance indicators used to measure SCRES is needed to enable synchronised quantitative studies in the future. This should be done by thoughtfully examining existing measures, and then either building on these or developing an entirely new SCRES measure based on insights gained from practitioners.

Building resilience against natural disasters at the SC level requires certain interactions and integration between members of the SC (Ponomarov & Holcomb, 2009; Scholten & Schilder, 2015). Accurate and timely communication, understanding and joint efforts of organisations could be the key to successfully building SCRES; that is, have a positive effect on SCRES performance indicators. Consequently, integrative practices between organisations

affected by natural disasters would need adjustments to support a temporary shift from the normal SC operations' goals of profit maximising and timely delivery to goals focusing on achieving better performance of SCRES building. These goals may include recovering to full operational performance more quickly to minimise financial losses. As the literature does not specify which supply chain integration (SCI) practice is important to address SCRES building and its key performance indicators, it is necessary to examine SCI inductively.

Therefore, the present study explores the meaning and interaction of three main concepts—namely, SCRES building as a process, SCRES building indicators (that will serve as a performance measure for SCRES) and SCI—under the contingency of natural disaster (see Figure 1-1).

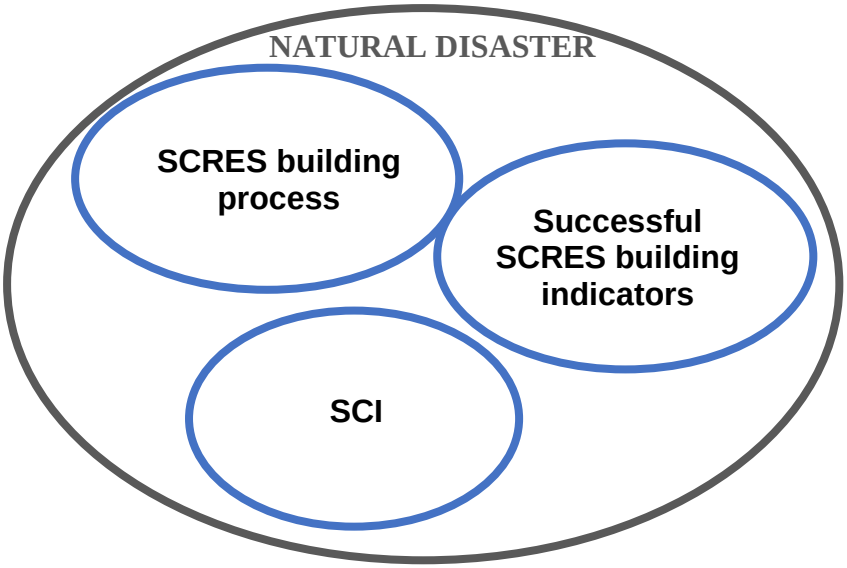


***Figure 1-1**: Three main concepts of research conduct*

1.2 Research Objectives and Research Questions

In accordance with the discussion above, the present study is designed to achieve the following three objectives:

Objective 1: determine how SCRES building works in practice and expand on the existing SCRES models

Objective 2: identify and describe performance indicators of successful SCRES building as a process and provide guidance for the development of a single, unique SCRES measure

Objective 3: clarify how SCI is utilised to support successful SCRES building and create a model that captures SCRES building, measurement insights and SCI that supports SCRES for future research.

To reach these objectives, the study examines the following research questions:

RQ1: How do SCRES building practices compare with existing SCRES building model from the literature?

RQ2: What are the performance indicators of successful SCRES building process that should be included in the measurement of SCRES?

RQ3*:* How is SCI utilised to support successful SCRES building?

1.3 Research Methodology

In addressing these three research questions, the present study collects data through interviews with SC managers who have experienced natural disasters. Secondary data, such as publicly available reports from government, companies and the media is utilised to support the primary data.

The present study aims to improve our understanding of SCRES in relation to natural disasters by advancing knowledge on this phenomenon through practical insights and investigation into the ways SCI is utilised to support SCRES. In doing so, the study applies a qualitative research design as it is most suited to the nature of this study (Tharenou, Donohue, & Cooper, 2007). Insufficient research of SCRES and inconsistency in the conceptual model, as well as lack of performance measure of SCRES building, mean the methodology needs to employ an inductive approach to data gathering and analysis (Ambrosini, Bowman, & Burton-Taylor, 2007). The inductive approach is applied to ascertain knowledge about resilience concerning natural disasters, as well as SCI adaptations to support SCRES. Interview data were analysed using template coding in the NVivo software package. This was further enriched with secondary data that was analysed in an inductive-deductive manner. Based on data analysis, the research frameworks of SCRES and SCI were developed, the developed models were

applied to the entire data sample, and a comprehensive framework was produced for future research.

Using the multiple case study approach, 13 different natural disasters are examined as 13 different contexts, involving 22 different SCs (Eisenhardt, 1989; Yin, 2009). Each context includes analysis of direct interviews with practitioners, enriched with supplementary secondary data. The study is also informed by structural contingency theory (Flynn et al., 2010; Lawrence & Lorsch, 1967), whereby a natural disaster is an overarching external contingency, and each of the 13 natural disasters present a specific context within this contingency.

1.3.1 Primary data collection

Exploratory, semi-structured interviews were conducted to examine the SCRES building process. The inductive nature of the interviews dictated open-ended questions about SCRES building. The literature provided only one SCRES model that focuses entirely on natural disasters as disruption. Therefore, SCRES building was examined relying on the model developed by Scholten et al. (2014), which consists of four stages: preparation, initial response, recovery and mitigation. This model was examined to identify the presence (if any) of additional elements of the constructs.

To recognise and capture the complexities associated with SCRES building in conjunction with SCI, the present study builds on Flynn et al. (2010). It examines SCI orientation (internal, with a supplier and with a buyer) and inductively captures other relevant SCI qualities that show relevance for SCRES building. Interviewees were asked questions about internal SCI, supplier SCI and buyer SCI. Additional time was provided during the interview for interviewees to describe interactions with other stakeholders relevant for SCRES, or provide any other information they considered relevant about SCI for SCRES building. After completing the first set of 10 interviews, the literature was revisited because interviewees indicated the presence of two additional orientations of SCI, with government and the community. They also distinguished between SCI with the supplier and SCI with the transport and logistic (T&L) provider. Further, the interviewees revealed that the nature of SCI is important for SCRES building (informational, operational and relational), as highlighted in the literature (Leuschner, Rogers, & Charvet, 2013).

The research relied on Farquhar's (2012) collective multiple case study guidance and undertook semi-structured interviews. This method allows more flexibility than structured interviews but offers stronger guidelines than unstructured interviews (Tharenou et al., 2007).

Thematic analyses to generate items were crucial to developing a concept (Hinkin, 1995). In this study, a total of 21 direct interviews with SC managers who experienced natural disasters were conducted and analysed. The analysis resulted in capturing new concepts, qualities of the existing concepts previously unnoticed in the literature and confirmation of some concepts already researched, all with the purpose of addressing the research objectives presented in Section 1.2.

To ensure validity and supplement the data collected through interviews, secondary data was also collected and analysed.

1.3.2 Secondary data collection

Secondary data on the natural disasters that affected the 22 SCs included in this study were also collected. After each interview, the specific natural disaster affecting the SC was examined in detail with all available data collected and analysed. Particular attention was dedicated to collecting secondary data that described the disaster development and its prolonged effect at the specific location involving the interviewee's organisation and its SC. In the case of a very large disaster, its impact on related industries was also examined in detail.

In total, over 350 different documents were analysed, including reports from governments, meteorological agencies, scientific institutions and private organisations. Scientific papers and published research, newspaper articles, media reports and other audio-visual material were also included.

1.3.3 Multiple case study

Each of the 13 different contexts of multiple case study correlates with one of the 13 different natural disasters that affected the 22 SCs. Following Creswell's (2013), Merriam's (1988) and Stake's (1995) guidance, the primary and secondary data was examined in terms of within-case analysis and cross-case analysis, with the primary purpose of addressing the RQs.

As part of the within-case analysis, each context included a description of the natural disaster, its development and effect. In addition, each context included a description of each SC affected by that natural disaster, its specific effect on that SC, the process of building SCRES against the natural disaster in that SC, and the SCI that took place to support SCRES building. Some contexts included only one SC, while others included two to four SCs. Table 1-1 lists the natural disasters and SCs included in the study.

As part of the cross-case analysis, all 13 contexts were analysed jointly, in relation to the three research questions.

Validity and reliability of the multiple case study as a research design were addressed following Yin (2009), Creswell (2013), Collis and Hussey (2014) and Bals and Tate (2018), and a codebook was developed.

***Table 1-1**: Natural disasters as a context and case SCs included in the study (case SC name and industry)*

Natural disaster—context of multiple case study	**SC name**	**Industry branch**
Queensland floods (2008)	Q1	Mining
	Q2	Retail
Tropical cyclone Tasha (2010)	T1	Agricultural
	T2	Food
	T3	(T&L) White goods
	T4	T&L courier
Hurricane Sandy (2012)	HS1	Automotive
Cyclone Lua (2012)	L1	Mining
Tropical cyclone Marcia (2015)	M1	Food
	M2	Non-perishable retail
	M3	White goods
	M4	T&L courier
West Australian floods (2017)	W1	Food
Cyclone Debbie (2017)	D1	(T&L) Automotive
	D2	Furniture
Typhoon Soudelor (2015)	TS1	Construction
Pacific Ocean typhoon season (2013)	PO1	Automotive
Anzac Day hailstorm (2015)	A1	Retail
	A2	(T&L) Healthcare
Australian flood after the Millennium drought (2010)	AM1	Agricultural
Eyjafjallajökull volcano eruption (2010)	VE1	(T&L) Perishable
Tohoku earthquake and tsunami (2011)	ET1	Automotive
Total number of natural disasters	**Total number of SCs**	
13	22	

1.4 Contribution of the Study

The present study contributes to existing research and practice in several ways. First, the study significantly contributes to the literature on OSCM in terms of understanding SCRES in relation to natural disasters. Primarily, this contribution involves distinguishing SCRES building as a process from SCRES building performance indicators that are utilised to measure successful SCRES building. This provides clarity to studies that struggle to see SCRES as a process or feature of SC. It enabled the development of a SCRES building model unique to this study that includes an additional stage (reconstruction) and two new operations (Early Anticipation and Opportunistic Operations) within the preparation and initial response stages. The study also establishes a set of three main SCRES performance indicators: time needed to restart operations, time needed to reach full recovery and financial losses caused by the natural disaster.

1.4.1 Reconstruction stage

SCRES building model was developed in this study based on Scholten et al.'s (2014) model. The new model provides clear guidance for practitioners and future research. Reconstruction is identified as an additional stage that can be utilised in future studies of SCRES in relation to natural disasters. Practitioners can use the new SCRES model to build and improve the resilience of their SCs by addressing performance indicators of SCRES building as a process.

1.4.2 Early Anticipation and Opportunistic Operations

Two additional operations were identified in this study, previously unnoticed in the literature. Early anticipation refers to the organisation holding additional stocks, beyond existing stock policy, to buffer the effects of a natural disaster. Opportunistic operations refer to opportunistic production and/or shipping after receiving warning of an approaching natural disaster. These two operations could be the crucial pieces of the puzzle that distinguishes SCs that successfully build SCRES from those that do not build SCRES into their SCs. This finding offers an additional area for future SCRES research, including SCRES performance indicators.

1.4.3 SCRES performance indicators

The existing research finds three main SCRES performance indicators: (i) time to restart any operations, (ii) time to reach operations to full capacity, and (iii) financial losses caused by the natural disaster. These correspond to the three main goals of operations within

SCRES building as a process: to reduce the time needed to restart any operations and to reach full operations, and to reduce the financial impact of the natural disaster.

Existing OSCM literature does not include the reduction of financial loses as a SCRES performance indicator, nor does it recognise different priorities of the indicators. These three performance indicators are prioritised differently according to the stage of SCRES building. While building SCRES in the reconstruction stage is only done to restart operations in any possible capacity, during the recovery stage, operations are focused on reaching full capacity. Further, the mitigation stage evaluates SCRES performance in terms of financial losses caused by the natural disaster. This enables researchers and practitioners to evaluate SCRES in terms of all three performance indicators and take appropriate action during each of the SCRES building stages, resulting in conducting operations more effectively.

The present research disagrees on the way how financial losses are evaluated, which highlights the need for standardisation of financial impact measures across both academics and practitioners. When a measure is standardised and diffused, the uniform application will result in a clear and comparable measure of SCRES.

1.4.4 SCI structure in relation to SCRES building

Previous research overlooked the possibility of different orientations and types of SCI practices providing somewhat different support in each SCRES stage. Researchers have examined the overall influence of collaboration on SCRES, trying to capture SCRES in terms of the time needed to reach full recovery (Scholten & Schilder, 2015; Van Den Adel, Scholten, & Van Donk, 2018). Initially, the present study approached the SCI concept inductively, recognising SCI orientation with buyers, suppliers and internally. The present study identified two additional stakeholders to consider as part of SCI orientation: government and community.

Further, the study identified SCI types relevant to observing SCI adaptations to support SCRES building. Informational SCI is concerned with information exchange, operational SCI focuses on the joint effort and tangible and intangible resource sharing, and relational SCI is concerned with understanding and relationships. After data coding applying these three types of SCI was conducted, this research found that operational SCI supports SCRES building, which concurs with previous research findings (Scholten & Schilder, 2015; Van Den Adel et al., 2018). However, the present research also found that use of operational SCI depends on the existence of informational and relational SCI. This will enable future research to test and evaluate these relationships. Additionally, this study provides valuable guidance for

practitioners in building strong communication and relationships in regular SC operations, outside the SCRES building cycle, so that those relationships can be utilised for joint SCRES building.

Moreover, the research founds that while SCI with government has the potential to improve SCRES building, practitioners' and governments' perspectives on this issue is contradictory. This study highlights the need for governmental organisations to communicate their desire to cooperate more clearly, which is another area for future research.

SCI with second-tier buyers and suppliers to support SCRES building is also identified as a new area of research that warrants further examination of the scope SCI's relevance (Frohlich & Westbrook, 2001) for SCRES.

Another major contribution of the present study to the literature is that SCI orientation is focused on the directly affected organisation (DAO). This was enabled by the different positions of interviewees' companies in relation to the effect the natural disaster had on their SCs. Some interviewees were able to witness this from the primary position of DAOs; for example, with their organisation directly affected by destroying winds or floods. Others witnesses this from the position of a DAO's buyer, supplier or T&L provider. This positioning of the relevant focus of SCI orientation enabled analyses of the different cases to be compared. It also provides guidance for future studies to help overcome the development of the SCI concept in relation to SCRES.

Also, trust has been inductively captured as a SC practice in descriptions of the nature of SCI effects on SCRES building. This suggests trust could be utilised to strengthen relationships between different stakeholders and serve as a tool for successful operational SCI utilisation in SCRES building. However, as trust was inductively captured, future research would need to investigate this further and test its strength. The study presents a research model that can be further evaluated in future studies.

1.5 Assumptions, Limitations and Delimitations

1.5.1 Assumptions

As the study involved empirical data collection from individuals who self-reported their experience, the following assumptions were made:

- Interviewees were able to adequately understand and comprehend the questions asked in accordance with the sense made by the researcher.

- Interviewees provided answers on behalf of their wider organisation and industry.
- The data collected during interviews is accurate, based on the knowledge and experience of the interviewees involved.

1.5.2 Limitations

Given these assumptions, this research was conducted with acknowledgment of the following limitations:

- The data was collected based on interviewees' perceptions.
- As the data for this study was collected from managers currently employed in Australia with global experience, the recommendations made and framework developed should be applied with caution to other contexts.

1.5.3 Delimitations

To manage the research process with maximum efficiency and within set time constraints for completion, the following delimitations were applied:

- The scope of the study focuses on SCRES; specifically, SCRES in relation to large-scale disruptions, namely natural disasters. Other large-scale disruptions were not included in the research, such as man-made disasters, as well as operational risks that appear in the literature, such as 'high frequency-low impact' disruption, including supplier change, market changes, demand fluctuation, innovation risks and uncertainty, and new product development.
- This study applies a structural contingency lens on the concept of SCRES. It is recognised that there are other available approaches to the study focus.
- The present study builds on Scholten et al.'s (2014) framework based on disaster management to explain SCRES being structured in four building stages in relation to natural disaster as a contingency. It is recognised that other frameworks might be utilised with the same purpose.
- The present study focuses on how SCI is utilised to support SCRES. It also inductively identified that trust may also be utilised. It is recognised that there are other possible supportive practices of the SCRES under natural disaster contingency.

- The present study applies Flynn et al.'s (2010) framework of SCI orientation and builds on it using inductive insights gained from practitioners. These inductive insights are attained in accordance with existing disaster management literature, including additional stakeholders; namely, government and community. It is recognised that there are other approaches to observe SCI.
- The present study inductively captures the importance of the nature of SCI, in the form of three main SCI types. This accords with Leuschner et al.'s (2013) work that distinguishes SCI as relational, operational and informational. It is recognised that there are other approaches to distinguish and categorise the nature of SCI.

1.6 Thesis Structure

The remainder of this thesis is structured as follows. **Chapter 2** focuses on a literature review of topics relevant to the research. Section 2.1 introduces the chapter and provides theoretical underpinning, establishing structural contingency theory as the foundation for the three main concepts under natural disaster contingency. Section 2.2 discusses SCs and SC management, and Section 2.3 presents a discussion of SCRES in terms of an historical overview of the research, models developed in previous research and model initially examined in this study. Section 2.4 considers the historical literature on SCI, and its definition and structure. The chapter then presents relevant research on SC performance in Section 2.5, the research questions in Section 2.6 and chapter summary in Section 2.7.

Chapter 3 explains the study's research design and methodologies utilised for data collection and analysis. Section 3.2 begins with a discussion on philosophical assumptions, describing phenomenological case study research and multiple case study research design. Section 3.3 considers the multidisciplinary nature of SCRES and presents the new model of SCRES developed in the study and the model of SCI applied.

Section 3.4 describes the data collection methods, covering interviews and secondary data. Direct interviews are discussed and their development is addressed, utilising Kvale (1996) and Marshall and Rossman (1995). Secondary data collection, including a list of all documents examined, is discussed. Section 3.5 explains the method used for data analysis. Thematisation data analysis utilising NVivo software is described, and analyses of primary and secondary data are addressed. Finally, the chapter reviews the study's validity and reliability in Section 3.6 and provides a chapter summary in Section 3.7.

Chapter 4 presents the findings of within-case analysis. This chapter details analyses of the data in the 13 different contexts, presenting one natural disaster within each context. Section 4.3 describes each natural disaster in terms of their nature, time and place of occurrence, duration and general effect. The SCs and SCRES building in relation to each natural disaster is also described, with each discussion later used in the cross-case analysis presented in Chapter 5.

After the within-case analysis was completed, the cross-case analysis took place. **Chapter 5** outlines these findings in relation to each research question (RQ). Section 5.2 presents the new SCRES building model and addresses RQ 1 of this study. Section 5.3 answers RQ 2 and presents findings related to SCRES performance indicators. Section 5.4 answers RQ 3 and provides findings on SCI in relation to SCRES building. The chapter concludes with a summary in Section 5.5.

Chapter 6 presents the discussion and contributions of the study, starting with a list of the key findings in relation to the research questions. Section 6.3 discusses implications for the key findings and Section 6.4 provides recommendations for the main stakeholders. Finally, the theoretical and practical contributions of the study are discussed in Section 6.5 and the chapter summary provided in Section 6.6.

Chapter 7 presents the key finding from this research and provides suggestions for future research in relation to these findings in Section 7.2. Section 7.3 discusses the limitations of the research and the suggestion for addressing these in future research, followed by a summary in Section 7.3.

1.7 Chapter Summary

This chapter has presented the background and the rationale of this study and outlined the research objectives, research questions and research design. The chapter has described the research contributions, assumptions and limitations of the study, and thesis structure. The following chapter reviews literature on the relevant topics in this study.

CHAPTER 2: LITERATUE REVIEW

2.1 Introduction

A review of the literature linking SCs and natural disasters will improve understanding of SCRES as a process that is conducted in a natural disaster contingency. This chapter will consider literature that addresses the concepts of SCI, SCRES building and performance indicators of SC operations. Each topic is examined according to scholars' definitions, explanations of structure and discussion in a natural disaster context.

Scientific research strives to avoid unnecessarily repeating previous studies and highlight the relevance and importance of new research topics (Tharenou et al., 2007). A literature review assists these goals and provides groundwork for developing research questions. In this chapter, Section 2.2 provides an historical overview of the theories applied to resilience research and discusses structural contingency theory, which is the theoretical framework employed in the present research. Section 2.3 reviews SCs and supply chain management (SCM), and Section 2.4 defines SCRES and describes SCRES building. SCI is explained in Section 2.5, and SC performance is addressed in Section 2.6. Finally, research questions are developed in Section 2.7, and Section 2.8 summarises the chapter.

2.2 Theory Applied in SCRES Research

2.2.1 Historical view on theories applied in SCRES research

Previous literature has utilised capability theory when conceptualising and researching SCRES (Aigbogun, Ghazali, & Razali, 2014; Brusset & Teller, 2016; Chowdhury & Quaddus, 2017; Fayezi, Zutshi, & O'Loughlin, 2010). Finessing these works, a number of scholars have presented SCRES as a set of capabilities, such as flexibility and agility (Braunscheidel & Suresh, 2009; Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007; Fayezi & Zomorrodi, 2015; Fayezi, Zutshi, & O'Loughlin, 2015; Jayaram, Xu, & Nicolae, 2011). While these studies provide a valuable foundation for the study of resilience in relation to predictable disruptions, their diminished value for unpredictable events is generally unrecognised in the literature.

Natural disasters carry a high level of uncertainty in terms of their development and the scope of their effects. As Scholten and Schilder (2015) observe, natural disasters pose great

uncertainty for SCs, not only in terms of the exact location of the initial impact, but also their strength and interaction with other natural and constructed phenomena. This collision can significantly increase both the financial damage caused by disasters and the scope of the area affected. Recognising this possibility, Van der Vegt et al. (2015) suggest resilience research needs to engage a contingent approach. This enables recognition of the specificity of a natural disaster as an external contingency and the high level of uncertainty these disruptions carry.

To capture the uncertainty specific to natural disasters, the present study utilises structural contingency theory and examines how SCRES is built, how SCI is utilised to support successful SCRES building, and the meaning of successful SCRES building in terms of performance outcomes.

2.2.2 Structural contingency theory

The study employs structural contingency theory as an overarching theoretical framework. As numerous scholars have observed, the meaning of business operations is, in many ways, dependent on the external environment (Koontz & O'Donnell, 1976; Negandhi & Reimann, 1972). Donaldson (2001) has rightly argued that these operations should be adjusted to fit environmental contingency. Building on Donaldson's understanding, the current study seeks to describe and explore how SC practices, especially SCI, may be altered as a consequence of the context forged by a natural disaster. Thus, structural contingency theory is utilised in this study to address SC operations, the SC practice of SCI, and SC performance. This approach asserts that original structures and processes may need to be adjusted to fit external contingencies (Donaldson, 2001; Milgrom & Roberts, 1995). To examine how this process manifests, researchers often use terms such as 'contingent upon' to describe previously established principles of 'fit' (Venkatraman & Prescott, 1990). Further, theoreticians have described negative performance outcomes that may occur as a result of 'misfit' (Donaldson, 2001). This relationship between fit and performance is central to the contingent approach.

When considering natural disasters and operations in relation to external contingency, the SC manager seeks to shape operations in ways that enable the organisation to cope with the expected contingency. Scholten et al. (2014) have theorised how SCRES building may be structured in four stages where the last stage *Mitigation* has the purpose to improve the first stage *Preparation* (see Figure 2-1), but this framework has not been applied to multiple case studies and its need for adaptation to fit this purpose is accepted.

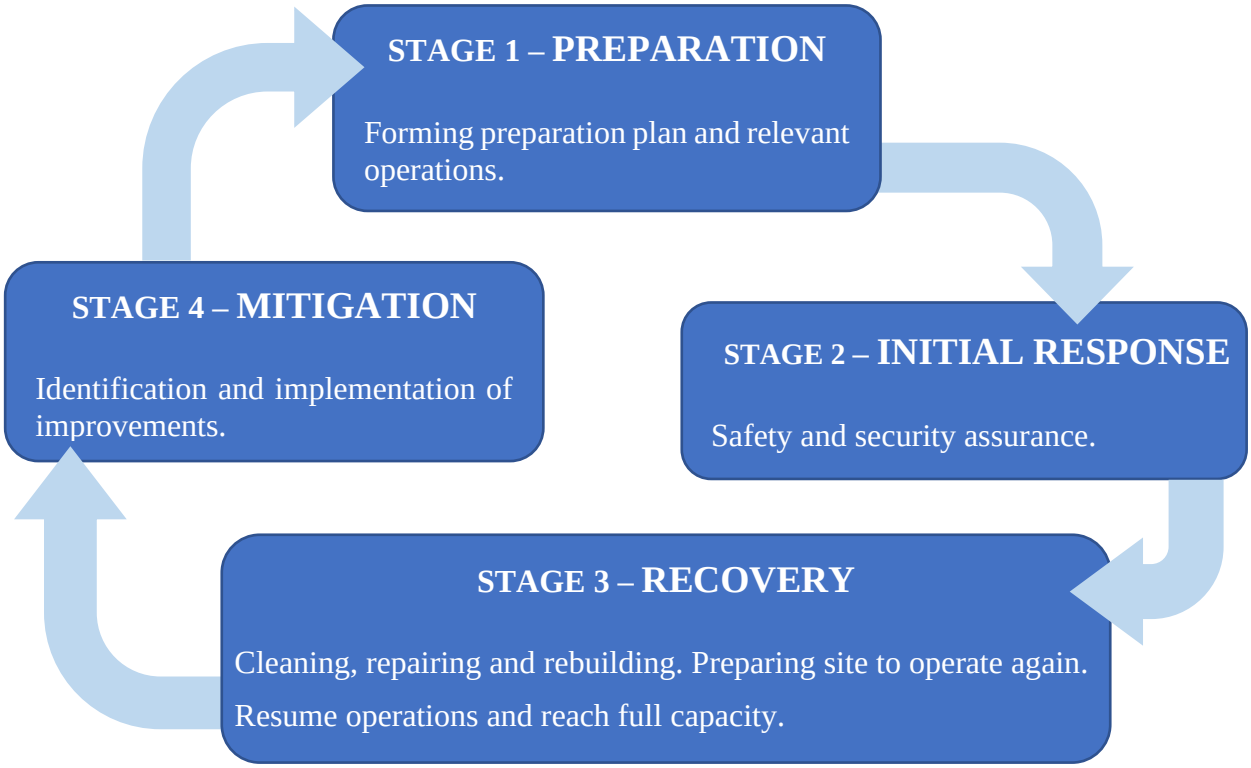


***Figure 2-1**: SCRES building process—concept structure in the form of four main stages as in Scholten et al. (2014)*

When operations are altered within one SC because of a natural disaster, interactions between companies in that SC may also need to be altered. These alterations can be made in SCI to support SCRES building as a process. Flynn et al. (2010) applied structural contingency lenses on SCI, recognising SCI orientation in terms of internal SCI, SCI with suppliers, and SCI with buyers (see Table 2-1). This thesis builds upon this structure while also drawing on Hambrick's (2005) assertion that understanding real-life phenomena requires exiting theory to be informed by practical insights from practitioners.

***Table 2-1**: SCI concept structure in terms of orientation*

SC practice	SCI structure: orientation	SCI orientation description
Supply chain integration (SCI)	Internal	Internal integration in the DAO or interviewee's company
	Suppliers	Integration between DAO and its suppliers
	Buyers	Integration between DAO and its buyers

When recovery is completed and SC managers try to derive knowledge from having experienced a natural disaster, they need to examine the SCRES building process in relation to their performance (Drazin & Van De Ven, 1985). They cannot use regular SC performance indicators, such as profit and delivery time, to evaluate how successful these operations were, because SC operations have different purposes when considering natural disaster effects. They need to evaluate the success of their SCRES building process against performance indicators contingent to natural disasters. This means the purpose of SCRES building has to be examined to identify and measure successful SCRES building. The existing research on SC performance indicates that it is evaluated in operational and financial terms (Cao & Zhang, 2011; Frohlich & Westbrook, 2002; Prajogo & Olhager, 2012; Singh & Power, 2014) when no contingency is applied. This brings an expectation that SCRES measures will also include financial and operational performance indicators.

2.3 Supply Chains and Supply Chain Management

SCs are networks of companies cooperating in undertaking various upstream and downstream activities to add value for the end customer and shareholders in the forms of service and product, and generation of an adequate rate of profit (Jayaram et al., 2011; Narasimhan & Jayaram, 1998; Visnjic Kastalli & Van Looy, 2013). Influenced by highly competitive markets and globalisation, today's SCs are producing and delivering services and products in all parts of the world, independent of the focal organisation location. In global operations, management of SCs demands significantly more effort than simple management of multiple companies. As Carter, Rogers and Choi (2015) observe, it requires establishing relationships, cooperation, strategic coordination and a systematic approach for further successful operations. SCM covers the flow of products, materials, finances and information in one company, and between the companies involved in the SC. These companies exchange crucial information based on existing trust and a common goal to improve the performance of each company and the SC as whole (Huo, 2012; Li, Yang, Sun, & Sohal, 2009; Mentzer et al., 2001; Zhang & Huo, 2013). Lambert and Cooper (2000) contribute to prior understanding of SCM by emphasising that this activity can only be performed by integrating crucial business processes in the entire SC, while Carter et al. (2015) highlight the importance of support provided by carriers.

Jayaram et al. (2011) state that a SC is comprised of suppliers, manufacturers and buyers. Building on this model, the current study recognises multiple tier suppliers, as well as

wholesalers, retailers and end customers as buyers of the firm. Notably, each node in this model can include multiple levels. For example, one manufacturing company might be supplied by multiple first-tier suppliers, such as an electricity provider, a raw material provider and an auxiliary material provider. In addition, those suppliers might have multiple suppliers providing them with materials, tools and equipment. Moreover, the manufacturer may cooperate with multiple wholesaling companies, each of which may distribute goods to several retailers that sell commodities to millions of customers. All these companies are further connected through specific T&L services (see Figure 2-2). One SC might include multiple T&L companies depending on the scope of operation, type of goods, or scope and type of services that local transportation companies provide.

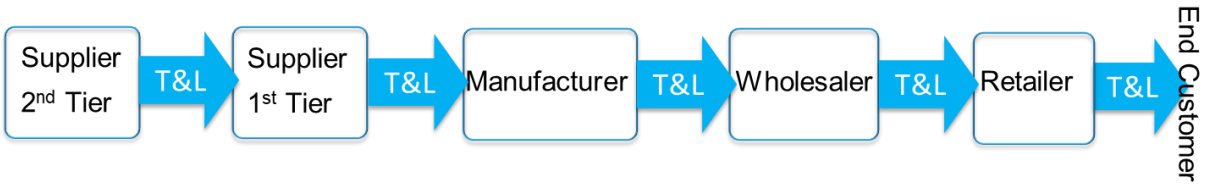


***Figure 2-2**: Overview of the typical supply chain model*

Thus, under normal circumstances, organisations that build and sustain a SC come together, exchange information, carry out joint operations and exchange products with the final goal of maximising profit in the long term and achieving on-time delivery (Narasimhan & Jayaram, 1998). Closely established relationships support the firm in building SCs that enable it to reach its overall goal of operational and financial performance (Devaraj, Krajewski, & Wei, 2007; Flynn et al., 2010). However, when a natural disaster affect one SC, the goals of on-time delivery and maximising profits might temporarily be substituted with goals related to SCRES, such as restarting critical operations and minimising financial losses. Therefore, patterns of interactions and SCI between companies in the SC might change to address these newly established performance indicators and support building SCRES. Relationships between companies in the SC may need to be adapted to suit their new purpose.

2.4 Supply Chain Resilience

2.4.1 Historical outline of resilience research

Resilience has been researched in multiple ways. Chronologically, ecology literature was the first to provide a definition of resilience, referring to it as an organism or system of organisms that stays stable or relatively stable during disruption (Holling, 1973; Smith &

Fischbacher, 2009). This concept equates with robustness in OSCM literature and indicates an ability to withstand the effect of external disruptions and continue operations through the crisis period (Tang, 2006b). However, SCRES cannot rely on this concept when discussing natural disasters because safety concerns tend to outweigh all other issues and demand operations cease. (Christopher & Peck, 2004).

When psychologists became interested in resilience, they recognised a stagnation period during periods of disruption or stress and certain personality attributes that contribute to resiliency before the subsequent trauma and recovery period (Friborg, Hjemdal, Rosenvinge, & Martinussen, 2003; Hobfoll, 1989). Afterwards, the individual normally proceeds to build skills, and analyse and apply knowledge on coping with consequences. This approach is strikingly similar to today's understanding of SCRES in OSCM.

Before engaging the term 'resilience', scholars have undertaken studies in risk management (RM), crisis management (CM), disaster management (DM) and related areas (Sadiq & Graham, 2016). In this literature, disaster effects are researched on the level of individuals, households, communities and public organisations (Henstra, 2010; Lindell & Perry, 2000; Mabuku, Senzanje, Mudhara, Jewitt, & Mulwafu, 2018; Miceli, Sotgiu, & Settanni, 2008; Milburn, Schuler, & Watman, 1983; Perry & Lindell, 1997; Siegrist & Gutscher, 2006; Somers, 2009; Stallings, 1973; Wachinger, Renn, Begg, & Kuhlicke, 2013). In the 21st century, the term began to be utilised in studies of natural disasters on private businesses (Burns & Slovic, 2012; Corey & Deitch, 2011; Han & Nigg, 2011; Sadiq & Graham, 2016), although this practice was infrequent (Han & Nigg, 2011; Zhang, Lindell, & Prater, 2008).

2.4.2 Defining the concept of supply chain resilience

Kamalahmadi and Parast (2016) observe that the OSCM literature recognises several different definitions of SCRES, depending on the contingency or the theoretical lens employed. The definition applied in resilience studies that considers all contingencies, including natural disasters, describes SCRES as:

The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function (Ponomarov & Holcomb, 2009, p. 131).

While this definition has value, Scholten et al. (2014) determined that it required adaptation if it was to be applied in studies focusing only on SCRES in relation to natural

disasters. Ponomarov and Holcomb's (2009) definition recognises three main stages of SCRES building: preparation, response and recovery. Scholten et al. (2014) argued it was necessary to extend this understanding by adding a fourth stage, mitigation, to address natural disaster contingency specificity and capture learning experiences from coping with one disaster to be implemented in response to subsequent ones.

In the same year, Brandon-Jones et al., (2014, pp. 55–56) defined SCRES as 'the ability of supply chain(s) to return to normal operating performance within an acceptable period of time after being disturbed'. In this definition, the authors posit that SCRES is not a potential, but an outcome. Although they use the word 'ability', what they describe is the time needed to return operations to full capacity. That time can only be measured as a performance indicator after completing the SCRES building process. This clearly indicates that SCRES building should be observed as a process, and SCRES should be measured in terms of performance indicators that assist effective evaluation of the process.

2.4.3 Supply chain resilience concept structure—Building stages

Nearly two decades of research on SCRES has resulted in 19 different frameworks from various disciplines. Frameworks for resilience building developed in the OSCM, DM and logistics management (LM) literature are presented in chronological order in **Table 2-2**. The red mark in the table indicates the moment in time when a natural disaster had an initial direct impact on the SC, while the green mark indicates when safety warnings were lifted and it was safe to return to the affected location.

***Table 2-2**: Resilience building stage, generated from OSCM literature, DM literature and LM literature*

Period before disruption				After initial effect of disruption			Safe for operations		Reference	Literature	Disruption addressed
	Discovery			Recovery				Redesign	Blackhurst et al. (2005)	OSCM	General
Risk management	Discovery						Recovery	Redesign	Kleindorfer and Saad (2005)	OSCM	Crisis (economic, natural, HR, terrorism)
Preparation				Assessment	Resources mobilisation	Procurement	Transport execution	Performance evaluation	Pettit and Beresford (2005)	DM & LM	Disaster (natural and man-made)
Preparation	First response			Initial impact	Preparation for recovery		Recovery	Long-term impact	Sheffi and Rice (2005)	OSCM	General
	Warning			Recovery					Craighead et al. (2007)	OSCM	General
Preparation				Immediate response			Reconstruction		Kovács and Spens (2007)	DM & LM	Disaster (natural and man-made)
Preparation and planning				Crisis			Post-crisis		Natarajarathinam, Capar and Narayanan (2009)	DM & LM	General
Readiness				Response			Recovery	Risk reassessment and organisational learning	Ponomarov and Holcomb (2009)	LM	General
	Identify hazard	Assess risk		Analyse controls	Determine controls	Implement controls		Supervise and review	Pettit, Fiksel and Croxton (2010)	LM	General
	Detection	Activation	Enhanced monitoring	Response			Adjustments	Organisational learning	Burnard and Bhamra (2011)	OSCM	General
Planning and preparation	Extreme conditions			During			Recovery		Leeuw, Vis and Jonkman (2012)	DM	Natural disaster
Anticipatory adaptation	Disaster sensemaking			Response			Reconstruction	Restoring to same or different level / Sensemaking and need for future adaptation	Linnenluecke et al. (2012)	DM	Natural disaster
Risk management	Discovery			Recovery			Redesign		Macdonald and Corsi (2013)	OSCM	Crisis (HR, security, natural, technology)
Preparation				Immediate response			Recovery	Mitigation	Scholten et al. (2014)	OSCM	Natural disaster
Readiness				Response			Recovery	Growth	Hohenstein et al. (2015)	OSCM	General
Preparation				Response and recovery				Growth or shortfall in performance	Tukamuhabwa et al. (2015)	OSCM	General
				Response as renewal	Response as replacement	Response as enhancement	Recovery and adaptation		Lawther (2016)	DM	Natural disaster
Anticipation	Resistance (control over structure and functions)				Recover and response (rapid and effective reactive actions)				Kamalahmadi and Parast (2016)	OSCM	General
Readiness	Recognition			Diagnosis	Development	Implementation			Bode and Macdonald (2017)	OSCM	General

Note: red = when natural disaster had initial direct impact on SC, green = when safety warnings were lifted, safe to return to affected location

The first set of resilience structures that appeared in the management literature in 2005 diverged markedly in terms of the number of stages identified and the location of the resilience practice in relation to the disaster's effect (Blackhurst, Craighead, Elkins, & Handfield, 2005; Kleindorfer & Saad, 2005; Pettit & Beresford, 2005; Sheffi & Rice, 2005). Interchangeable utilisation of terminology induced additional ambiguity within the literature. For example, actions conducted under the recovery stage engage different points in time in the studies of Blackhurst et al. (2005) and Kleindorfer and Saad (2005). The former includes an initial response to disruption, such as alarming, protecting the facility and safety actions enforcement in the recovery stage, while the latter completely excludes these operations from this stage and starts recovery after safety warnings are lifted, leaving no description of operations between disruption discovery and the recovery stage.

While most of the studies in the literature recognise the recovery stage, some researchers identify mitigation as a stage that follows recovery and informs the preparation stage. Yet, even in this area, some ambiguity remains. For example, Craighead et al. (2007) identify a warning stage that corresponds to preparation and recovery and deem it part of the mitigation stage. Contrastingly, Tukamuhabwa, Stevenson, Busby and Zorzini (2015) present response as a set of actions that are part of the recovery but not an independent stage, which renders terminology even more confusing.

Stages of SCRES building are also observed from the perspective of the object of effects and the effects themselves. This is visible in Sheffi and Rice (2005), where one stage is named 'initial impact' while other studies emphasise actions taken by directly affected organisations in response to initial impact, such as 'response' (Hohenstein, Feisel, Hartmann, & Giunipero, 2015; Linnenluecke, Griffiths, & Winn, 2012; Ponomarov & Holcomb, 2009), 'immediate response' (Kovács & Spens, 2007; Scholten et al., 2014), 'diagnosis' (Bode & Macdonald, 2017) and 'assessment' (Pettit & Beresford, 2005) (see -2).

The presence of multiple stages of SCRES building in the literature, the overlapping of stages in different timeframes and inconsistent employment of terminology indicates that additional research is needed to justify the selection of one of the existing SCRES building frameworks. In the structural contingency approach, which considers the environmental contingency of natural disasters, Scholten et al.'s (2014) resilience-building framework has the greatest potential for further understanding of resilience relating to natural disasters. As this study focuses only on natural disaster contingency and heavily relies on DM literature, it accepts insights on the specificities of natural disasters as a disruption. Thus, the present study

applies Scholten et al.'s framework, and holds that SCRES building is a process that includes four major stages: preparation, initial response, recovery and mitigation. These stages are embedded in the understanding of the DM process and accepted as resilience-building stages in this thesis.

The preparation stage stands for the establishment of a team, analytics of capabilities and potential hazards, and development and implementation of safety, contingency and other plans. In the DM literature, this stage includes enacting legislation, training, exercise, infrastructure protection and engagement with a broad range of stakeholders (Henstra, 2010). The initial response is the first response after acknowledging the immediacy of the disaster, in the moment when disaster affects the supply chain, or immediately before that moment. The firm affected implements a response plan and evaluates direction, control, communication, and safety and security measures to preserve life and property. The emergency is triggered when hazards occur and threaten business operations or properties (Henstra, 2010). The third stage, recovery, is applied after the immediate danger associated with the disaster has passed. Recovery plans are implemented and reviewed, continuity management enforced, and employee support is maintained with the main goal being to resume or recover operations. After operations are fully resumed the fourth stage, mitigation, is launched. This entails identification of mitigation opportunities and continuous improvement plans, which informs the preparation stage for the next event.

2.4.4 Supply chain resilience contingent view

Resilience has received significant attention from OSCM researchers in the last two decades, starting with Sheffi (2001). However, the majority of studies, including Christopher and Peck (2004), Rice and Caniato (2003), Sheffi (2001) and Tang (2006a) began researching SCRES as a general term and did not focus on specific contingencies, Macdonald and Corsi (2013) introduced a more precise focus by concentrating on severe and sudden disruptions, and Pettit et al. (2013) examined several specific contingencies, including recognising natural disasters. Subsequently, Van der Vegt et al. (2015) and Brusset and Teller (2016) recognised that different operations and routines have divergent effects on SCRES, with the effect being a function of the nature of the disruption, while Day (2014), Matsuo (2015), Scholten and Schilder (2015) and Scholten et al. (2014) focused on SCRES in relation to natural disasters only.

The inattention accorded to specific contingencies when defining and researching SCRES meant that SCRES building against an unreliable supplier and a tsunami was performed in the same manner and measured against the same indicators. This approach had its advantages in generalisability, but has created confusion in the literature, especially in terms of the overlapping concepts of robustness and resilience. As already noted, robustness is important for SCs when building SCRES in normal circumstances, but may be impossible when building SCRES relating to natural disasters. When deliveries by a major supplier are delayed, SCs have to be able to continue operations, which means being robust. However, when a tsunami threatens to wash out facilities, the affected SC must stop operating. Being robust and continuing operations in these conditions only posit more challenges to successful SCRES building due to greater losses.

In conclusion, the present study addresses SCRES relating to natural disasters in a manner that distinguishes resilience from robustness. It researches SCRES building as a process and recognises that SCRES can be measured in terms of the outcome of effectiveness in conducting that process.

2.5 Supply Chain Integration

SCI presents the core aspect of SCs that supports their operation in normal circumstances. Effective integration entails close communication, cooperation and a strong relationship between integrated organisations (Stevens, 1989). Following the above format, this section provides an historical overview of SCI research, a definition of the concept and an outline of influential SCI frameworks, and concludes with a discussion of the structure of SCI.

2.5.1 Historical outline of supply chain integration research

SCs consist of networks that entail multiple business relationships rather than one-to-one company relationships (Carter et al., 2015; Lambert & Cooper, 2000). SCM includes the integration of all business processes between independent companies. It includes management of goods, services and information from the first supplier to the final customer, with the goal of reducing overall cost and maintaining required service levels and on-time delivery (Christopher, 1998; New & Payne, 1995; Smichi-Levi, Kaminsky, & Smitchy-Levi, 2000; Tang, 2006a; Wisner, 2003). SCI embedded between organisations in one SC can strongly support SC performance.

Armistead and Mapes (1993) began investigating SCI in terms of its influence on SC performance in normal circumstances. In the new century, scholars began expanding on these initial contributions in numerous ways, including the scope of SCI, utilisation of information technology and the effect SCI had on SC performance (Chandra & Kumar, 2001; Dainty, Briscoe, & Millett, 2001; Frohlich & Westbrook, 2001; Nissen, 2001). These studies generated divergent findings. Devaraj et al. (2007), Flynn et al. (2010) and Leuschner et al. (2013) found SCI has a positive impact on performance claimed. Graham and Potter (2015), Jayaram et al. (2011) and Wieland and Wallenburg (2013) questioned this determination and concluded that the relationship is contingent.

Subsequently, different practices associated with SCI were examined in terms of their influence on SC performance. For example, SCI has been researched in terms of information sharing (Singh & Power, 2014), communication (Wieland & Wallenburg, 2013), information technologies employment (Devaraj et al., 2007; Jitpaiboon, Dobrzykowski, Ragu-Nathan, & Vonderembse, 2013) and longevity of the relationship with suppliers (Zhao, Huo, Selen, & Yeung, 2011). In brief, it has become accepted that studies of SCI in relation to SC performance should recognise different types of SCI activities and application of specific contingency.

2.5.2 Defining the SCI concept

Zhao, Huo, Flynn and Yeung (2008, p. 374) advanced a comprehensive definition of SCI that considers the concept internally, with a supplier and with a buyer:

SCI (as supply chain integration) is the degree to which an organisation strategically collaborates with its SC (supply chain) partners and manages intra- and inter-organisation processes to achieve effective and efficient flows of products, services, information, money and decisions, with the objective of providing maximum value to its customers.

This definition is adopted in the present study because it applies structural contingency theory while accepting the structure of SCs as described in Section 2.2. Further, the objective of this study is to understand how SCI supports SCRES building in a comprehensive manner. This definition enables this objective to be addressed, as it recognises all three orientations of SCI examined in the previous literature: internal, with a supplier and with a buyer.

Supply chain integration frameworks

To examine how SCI is utilised to support SCRES building under natural disaster situations, the present study relies on Flynn et al. (2010), who also utilise Zhao et al.'s SCI definition, meaning they engage internal SCI, SCI with a supplier and SCI with a buyer.

Considering a natural disaster contingency, the SCI orientation proposed by Flynn et al. (2010) an be expanded to include community and government, as posited by Blakely and Bradshaw (2002), Runyan (2006), Wilson, Tatham, Payne, L'Hermitte and Shapland (2018) and Zhang et al. (2008). The present study examined this SCI orientation inductively. After cross-examining the data and literature, these two additional orientations (community and government) were incorporated into the framework, while SCI with a supplier of goods and SCI with a T&L provider emerged as separate orientations from SCI with any supplier generally.

In addition to recognising SCI orientation (Zhao et al., 2008, p. 374), Frohlich and Westbrook (2001) envisioned SCI as arcs with different widths (see Figure 2-3). They argue that the extent of integration is an important attribute that influences SC performance, which means integration beyond first-tier suppliers and first-tier buyers needs to be considered; that is, integration with second-tier buyers and beyond. This makes sense in light of Frohlich and Westbrook's (2001) findings that this practice may be crucial for successful operations. Therefore, it can be assumed that the scope of SCI on one SC might significantly influence SC performance in undisturbed and disturbed conditions.

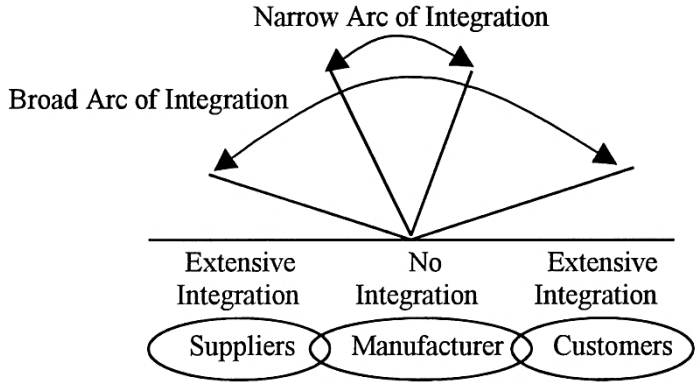


***Figure 2-3**: Arcs of integration (Frohlich & Westbrook, 2001, p. 187)*

SCI is also analysed using divergent conceptual frameworks in terms of practices considered as SCI. Consequently, integration with a supplier in one study might be viewed as a completely different practice than SCI with a supplier in another study. For example, Narasimhan and Kim's (2002) framework includes only information exchange, while Flynn et al. (2010) consider communication, information sharing and joint teamwork. Swink, Narasimhan and Wang (2007) examine close contact with customers and joint teamwork as

part of SCI with suppliers. The literature not only disagrees on the type of SCI activities to examine, but also whether to include attitudes towards SCI, patterns of behaviour and practices as separate elements (van der Vaart & van Donk, 2008).

Leuschner et al. (2013) enrich existing frameworks that differed in practices examined by considering three types of SCI: informational, operational and relational. They explain that this categorisation is needed to build an effective and common framework that can be utilised to identify and compare different effects of SCI on SC performance. Hence, Leuschner et al.'s (2013) framework is embraced and informs this thesis.

Figure 2-4 captures all three dimensions of the SCI concept—SCI orientation, SCI type and SCI scope—to introduce multiple dimensions into the framework applied in this study. This is visually represented by building on Frohlich and Westbrook's (2001) framework.

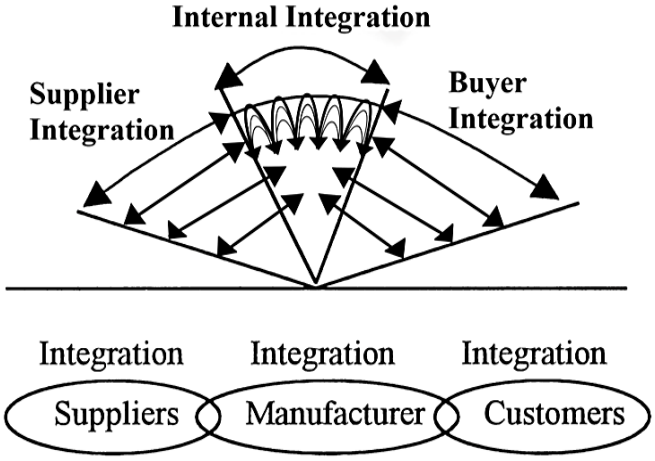


***Figure 2-4**: Arcs of integration (adapted from Frohlich & Westbrook, 2001, p. 187)*

2.5.3 Structure of the supply chain integration concept

Supply chain integration orientation

Contemporary management literature locates SCI in two broad clusters: internal and external SCI (Campbell & Sankaran, 2005; Das, Narasimhan, & Talluri, 2006; Droge, Jayaram, & Vickery, 2004; Flynn et al., 2010; Morash & Clinton, 1998; Pagell, 2004; Schoenherr & Swink, 2012). Internal and external SCI play different roles in enhancing SC performance in regular operations outside natural disaster contingencies. Further, they can be utilised in a different manner to support SCRES under a natural disaster contingency. External integration plays a significant role in building relations between organisations. Their joint effort can be

invested in ways that limit the transfer of negative effects of the natural disaster through the SC. Conversely, internal integration focuses on single organisations that are directly affected by a natural disaster and questions how departments in that company function together when building SCRES.

Internal supply chain integration

The internal SCI literature focuses on practices among departments and employees within one organisation and how collaboration can support customer requirements at the lowest cost (Stank, Keller, & Closs, 2001). As Flynn et al. (2010) observe, well-integrated organisations have departments that interact and communicate (see also Schoenherr & Swink, 2012; Wong, Boon-itt, & Wong, 2011). However, poorly integrated departments in an organisation can create confusion and duplication of work, waste resources and create unwanted excess in inventory (Stank et al., 2001). This could be costly in terms of finances and time, and significantly influence the operational and financial performance of both the organisation and the entire SC (Pagell, 2004).

Wong, Boon-itt, et al. (2011) observe that in the presence of small disruptions, such as may occur with an unreliable supplier or market changes, internal SCI in terms of fast and accurate information exchange tends to support SCRES. Managers and employees who are well informed about the internal difficulties that can occur when dealing with disruption, have better insights and evaluate additional options for successful recovery (Follett, 1993; Roth, 1996; Wong & Hvolby, 2007). Further, internal SCI enables knowledge and resources sharing between different teams in the organisation, which helps them overcome the challenges faced (Keller, 2001; Swink & Schoenherr, 2015). This indicates that internal SCI can potentially support SCRES in relation to natural disasters.

The DM literature explores resilience at an organisation level, and finds that managers who improve communication among employees are more effective and competent in a crisis (Olejarski & Garnett, 2010). In addition to information exchange, supportive behaviour was found to assist resilience building from planning to complete recovery. Collegial management and care for relationships among employees resulted in employees' respect for the organisation. Consequently, employees' engagement increased, which led to faster recovery (Olejarski & Garnett, 2010). Further, non-verbal elements of communication within organisations were found to be highly important in determining an organisation's effective response in critical situations (Milburn et al., 1983). However, the potential of using internal SCI for SCRES

building in the case of natural disasters has been under-explored in the literature and hence, investigation of this issue is warranted.

External supply chain integration with supplier and buyer

Flynn et al. (2010) initiated research into external SCI by considering the integration of the organisation with both supplier and buyer. Supplier SCI grasps cooperation between a supplier company and focal company (Bensaou & Anderson, 1999; Droge et al., 2004; Flynn et al., 2010), explaining their interactions in terms of strategic partnerships, business processes, information sharing, collaboration and planning. Buyer SCI relates to cooperation of the focal company and its buyer(s) (Bensaou & Anderson, 1999).

There are disadvantages to a low external SCI or too extensive external SCI in normal circumstances. Low SCI with a buyer could lead to a low quality of demand information and general information about cooperation requirements, resulting in excessive production or low buyer satisfaction (Droge et al., 2004; Lee, Padmanabham, & Whang, 1997; Vickery et al., 2003; Wong, Boon-itt et al., 2011). It could result in misunderstanding and cause unnecessary conflict (Flynn & Flynn, 1999). Similarly, low SCI with a supplier leads to uncertainty of regular supply and ability to fulfil buyer expectations and address the main performance goals (Bensaou & Anderson, 1999). A high level of integration with a supplier may result in dependency on that supplier and limit the focal company's option in cases of supply interruption (Bensaou & Anderson, 1999). Similarly, a high level of integration with a buyer may result in the buyer demanding reduced prices and restrict potential market development.

In normal circumstances, SCI between organisations is adjusted to support operational and financial performance. However, in a natural disaster circumstance, SCI may need adjusting to support SCRES building related performance. For example, information flow and visibility through SC were found to be crucial in facing sudden and severe disruptions (Gavirneni, Kapuscinski, & Tayur, 1999; Jüttner, 2005; Kamalahmadi & Parast, 2016; Pettit et al., 2010). In this case, it was found that organisations were able to exchange information on severe disruption and potential ways to overcome its consequences. Organisations had a chance to react rapidly, coordinate damage control, avoid duplication of effort and identify new opportunities arising from the difficulties (Christopher & Peck, 2004; Lee, 2004; Pettit et al., 2013; Scholten & Schilder, 2015; Swafford, Ghosh, & Murthy, 2008). Moreover, during the mitigation stage, communication and close collaboration can be utilised to evaluate the effect of the natural disaster and response to that effect, allowing new insights and potential improvement of SCRES building (Kamalahmadi & Parast, 2016; Pettit et al., 2013).

Communication and collaboration with a supplier can support natural disaster SCRES building. For example, DAO may need different amounts and types of supply than normal because goods were lost or damaged by the natural disaster. If these orders are well-coordinated, DAO may receive supply promptly and make up for non-operational time. Moreover, deep understanding of a DAO situation may induce suppliers to accept delayed payment conditions to support recovery. Conversely, strong communication and relationships with a buyer can ensure buyers will return to cooperation with DAO. The buyer could show understanding for DAO and avoid imposing additional pressure on an organisation that is already struggling to recover. Moreover, if delivery of the product is not urgent, buyers may prefer to wait for the organisation to recover rather than find another supplier. Therefore, SCI with suppliers and buyers can be utilised for SCRES building. However, the extant literature lacks a comprehensive understanding of how this can be done.

Additionally captured supply chain integration orientation

In the following sub-sections, aspects of SCI structure not included in the initial literature review undertaken for this thesis are presented. The additional aspects were identified when data analysis was undertaken and involved two additional SCI orientations: government and the community. The analysis also elucidated the need to recognise SCI types—informational, operational and relational—and include these in the study.

Government and community

Consideration of supplier, buyer and internal SCI is sufficient for SC operations in normal circumstances. However, natural disaster contingency dictates that directly affected organisations may need to integrate with a wider range of stakeholders, and additional SCI orientations may be relevant to support SCRES building. In the present study, collected data indicated that public organisations and community play a significant role in SCRES building. The public sector and community can have an important impact on business operations. Maintaining relationships with these stakeholders is required for SC operations, although they do not demand as much attention as buyer, supplier and internal relationships for SC performance during regular circumstance. However, these stakeholders can be very important for SCRES building relating to natural disasters. Consequently, disaster relief studies have recognised that under certain circumstances, public organisations, private organisations and communities come together to confront natural disasters with a common goal of restoring and re-establishing more normal conditions (Day, 2014; Kovács & Spens, 2007).

Government influences businesses through law, regulation, subsidies and the imposition of responsibilities (Blakely & Bradshaw, 2002). Public institutions supply infrastructure in terms of roads and lifeline facilities, such as electricity, fuel, water and sewer, telephone landlines and, in some cases, supporting structure for internet and mobile telephone network providers (Kroll, Landis, Shen, & Stryker, 1990; Zhang et al., 2008). When the region within which a supply chain operates is affected by a natural disaster, a substantial understanding of public organisations' priorities in restoring road networks and lifeline services can hasten the restart of SC operations (Kroll et al., 1990). Good communication with the public sector and policy makers enables local SCs to identify which roads or rails are trapping significant volumes of their products and/or resources. The region major perishable manufacturing is located in might need electricity supply more urgently than other areas. Recent studies on SCRES and relief agencies began recognising the importance of a joint effort in SCRES building with governmental organisations (Wilson, et al., 2018).

Public institutions could also be buyers of services or products from the private sector. In the aftermath of a natural disaster, it is highly probable that government or their agencies will seek supplies from private companies with which they have already established relations. This may accelerate the recovery of a SC if it means demand for product and services is increased and cash flow enhanced.

Communities can play a significant role in the recovery of SCs. Some authors go so far as to call private firms a 'community's private sector' (Atkinson, 2014, p. 148) to highlight the interdependence of organisational community resilience building. This is logical because community supplies businesses with both employees and customers (Zhang et al., 2008). Therefore, community recovery may play a crucial role in the SCRES. For example, during the 2005 Katrina hurricane, housing and infrastructure were destroyed in New Orleans, USA. As Runyan (2006) observed, most residents were forced to leave the area until biological safety was reached or their homes were repaired. Three months after the hurricane, a majority of the population still had not returned to the area. This had a tremendous effect on local businesses. Employees left the area, so there was a lack in the workforce needed to restart operations, and companies with employees available struggled due to a shortage of customers. Further, returning residents needed large quantities of products, including construction materials, electrical appliances, furniture and cleaning equipment. Therefore, the companies that are first to offer the required amounts of products and restore purchasing power in the affected market might even generate increased profit and recover completely quickly. Finally, Wilson et al.

(2018) notably recognise the importance of acknowledging community expectations in SCRES building due to businesses' dependence on the community.

Additionally captured supply chain integration types

Leuschner et al. (2013) identify three types of SCI: informational SCI, operational SCI and relational SCI. Table 2-3 provides descriptions of each SCI type.

***Table 2-3**: Types of SCI (Leuschner et al., 2013)*

SCI type name	SCI type description
Informational	Information and knowledge sharing among parties, sharing plans, or data in any manner, with or without information technology utilisation for information sharing.
Operational	Joint teams, joint coordination of operational processes and activities, including sharing of tangible and intangible resources, such as sharing time, finances or equipment.
Relational	Mutual understanding and stronger human-level connection, social bonding between parties, description of interaction as open and honest, trust and long-term focus while working together.

Informational SCI essentially presents integration between parties in terms of information exchange. It includes information sharing, knowledge sharing and communication. In the context of this study, information SCI has a contingent nature and communication to support SCRES building will be examined, including communication about approaching natural disasters, the expected effect, the operations interrupted due to the damage caused by the disaster, and the progress of the recovery.

Operational SCI includes sharing tangible and intangible resources. Parties come together to create joint teams; they invest time, finances or equipment in the common goal; they coordinate their efforts and collaborate. In the context of this study, operational SCI includes parties addressing the common goal of building SCRES with utilisation of resources from both sides, such as organising joint teams to produce joint preparation plans for a natural disaster or T&L services.

Relational SCI refers to strategic partnerships and long-term orientations. It requires a higher level of trust between parties and includes social bonding, building strong relationships,

open and honest communication, and genuine understanding between parties. When confronting a natural disaster, company sectors that trust each other react faster and build SCRES more effectively.

2.5.4 Supply chain integration contingent view

Numerous scholars have recognised that SCI is important to support SC performance in undisturbed conditions (Flynn et al., 2010; Gavirneni et al., 1999; Lee, 2004; Leuschner et al., 2013; Narasimhan & Kim, 2002; Pagell, 2004). The majority of this research tests SCI influence on operational and financial performance in the abstract (Cao & Zhang, 2011; Świerczek, 2014; Wiengarten, Humphreys, Gimenez, & McIvor, 2016; Wong, Boon-itt et al., 2011). However, OSCM started recognising that SCI practices needs to be modified to address specific contingencies, and that their influence on performance should be researched in relation to specific environmental conditions (Christopher & Holweg, 2011; Ralston, Blackhurst, Cantor, & Crum, 2015; Terjesen, Patel, & Sanders, 2012; Wong Boon-itt et al., 2011). Contingencies recognised include factors determined by geography (Cao & Zhang, 2011; Huo, 2012; Zhang, Van Donk, & van der Vaart, 2016), innovation (Liao & Kuo, 2014; Singh & Power, 2014), external uncertainties of market turbulences (Braunscheidel & Suresh, 2009; Chen, Mattioda, & Daugherty, 2007; Chen, Sohal, & Prajogo, 2013; Yu, Jacobs, Salisbury, & Enns, 2013) and any disruption in general (Brusset & Teller, 2016; Christopher & Holweg, 2011; Świerczek, 2014; Wiengarten et al., 2016;). SCI effect on performance in relation to SCRES against natural disasters has only recently entered the literature (Scholten & Schilder, 2015; Van Donk, Sancha, & Scholten, 2017;). Table 2-4 presents the latest research on SCI and its performance outcomes, considering specific contingencies.

***Table 2-4**: Recent studies on SCI performance outcomes with contingencies considered*

Contingency / References	Location	Market, competition and customers	Innovation	Natural disaster	General disruption
Chen, Mattioda et al. (2007)		✓			
Lee, Kwon et al. (2007)	✓				
Swink, Narasimhan et al. (2007)		✓			
Braunscheidel and Suresh (2009)		✓			✓
Kim (2009)		✓			
Lawson, Cousins et al. (2009)	✓				
Li, Yang, et al. (2009)					
Villena, Gomez-Mejia et al. (2009)	✓				✓
Danese, & Filippini, (2010).					
Lau, Yam et al. (2010)	✓				
Cao and Zhang (2011)	✓				✓
Christopher and Holweg (2011)					✓
Jayaram, Xu et al. (2011)	✓				
Wong, Boon-itt et al. (2011)					✓
Wong, Lai et al. (2011)					✓
Huo (2012)	✓				
Terjesen, Patel et al. (2012)					✓
Chen, Sohal, Prajogo (2013)		✓			
Yu, Jacobs et al. (2013)	✓	✓			
Lai, Wong et al. (2014)	✓				
Liao and Kuo (2014)			✓		
Singh and Power (2014)	✓		✓		
Świerczek (2014)					✓
Wiengarten, Pagell, et al. (2014)					
Scholten and Schilder (2015)				✓	
Wiengarten, Humphreys et al. (2016)					✓
Zhang, Van Donk et al. (2016)	✓				
Brusset and Teller (2016)					✓
Van Donk, D. P., et al. (2017)				✓	
Van Den Adel, Scholten, et al. (2018)					✓
Total number of studies	**11**	**6**	**2**	**2**	**11**

The majority of contingencies—such as location-specific attributes, market turbulences and innovation—are easily predicted or even planed. Therefore, their possible effects on SCs can be prevented, as they are well-known and anticipated. Consequently, SCI influence on performance has been researched to determine the impact of SCI on SC capabilities, such as agility, flexibility and fast reactions.

There is often uncertainty regarding the precise character and impact of a natural disaster (Corey & Deitch, 2011; Lawther, 2016), and even more so if they induce cascading events that hamper the SCs' ability to recover from the initial disaster (Boin & Lagadec, 2000; Eshghi & Larson, 2008; IFRC, 2016; Smet et al., 2012). Moreover, as Scholten et al. (2014) observe, SCs may experience other risks, such as unstable demand due to affected customers and their purchasing power, market price fluctuations due to the industry being undermined, and unreliable supply due to affected infrastructure or effect on suppliers. In cases where these accrued effects were not predictable, organisations were unprepared (Kovács & Spens, 2007). Therefore, SCI can play an even more significant role in the absence of well-established plans.

Vogus and Sutcliffe (2007) recognised that SCs and their internal relationships might need adjustments to support SCRES. Therefore, SCI should be examined according to the adjustments made to support SCRES building as a process, and the effects on SCRES related performance indicators measured. Since the purpose of SC operations during SCRES building under a natural disaster contingency is not the same outside this contingency, performance indicators also differ.

2.6 Supply Chain Performance

2.6.1 Defining the concept

Beamon (1999) explains that performance indicators can only be identified when the purpose of business operations is first considered. Goals can be identified based on that purpose, and it is only then that indicators can be recognised as a measure of successfully reaching goals. Beamon (1999) contends that SC performance is measured using different indicators based on different goals.

Mentzer et al. (2001) argue that maximising overall and long-term SC is the purpose of SC operations in undisturbed conditions. Generally, the OSCM literature agrees that SC performance is judged on the extent to which SC operations meet the requirements of the end customer in a profitable manner (Carr & Pearson, 1999; Frohlich & Westbrook, 2002; Gu,

Jitpaipoon, & Yang, 2017; Hausman, 2004; Koufteros, Vonderembse, & Jayaram, 2005). These goals can be operational and financial, as the definition itself suggests. Financial performance is presented as a set of indicators that include costs and returns on investment, while operational performance is presented as time and accuracy indicators. The following section discusses SC performance in terms of two main categories, and presents an historical outline of research on the topic, followed by a contingent view of performance indicators.

2.6.2 Historical outline of the supply chain performance

Previous research reported in the OSCM literature has identified various ways to measure SC performance. While each indicator category has a valid justification for a specific research focus, this made the selection of an appropriate definition and category complicated (Beamon, 1999). Two major SC performance categories are financial performance, also called cost or business performance, and operational performance.

Financial performance is commonly measured in terms of the organisations and extended to the level of the SC. Financial performance indicators come from the goal of profit maximisation. Success in reaching this goal is measured using various indicators, such as sales or growth in sales, return on investment, return on assets, production cost, inventory cost, delivery cost, management cost, profit margin, and market share or growth in market share (Cao & Zhang, 2011; Das et al., 2006; Handfield, Petersen, Cousins, & Lawson, 2009; Huo, 2012; Wiengarten et al., 2016; Wong, Lai, et al., 2011; Wu, Chuang, & Hsu, 2014; Yu et al., 2013). When extended to the SC level, these indicators include total SCM cost, inbound and outbound cost, logistic costs and similar (Frohlich & Westbrook, 2001, 2002; Leuschner et al., 2013; Wiengarten et al., 2016; Wong, et al., 2011; Yu et al., 2013)

Operational performance is evaluated at the SC level. It is measured by indicators related to delivery, including examining delivery accuracy, on-time delivery or delivery speed, customer satisfaction with delivery, and quick modification to address customer requirements (Braunscheidel & Suresh, 2009; Cao & Zhang, 2011; Droge et al., 2004; Flynn et al., 2010; Frohlich & Westbrook, 2001, 2002; Swink et al., 2007; Wu et al., 2014; Yu et al., 2013; Zhao et al., 2011). Some authors also focus on the responsiveness of production to market changes and therefore measure product modularity (Ralston et al., 2015), product introduction time and development time (Droge et al., 2004; Flynn et al., 2010), and general reactivity to change (Thun & Hoenig, 2011).

Categorisation is even more refined in some studies, such as in Swink et al. (2007), where growth in sales, market share and profit were categorised as market performance, while others simply put all mentioned indicators under one performance measure without categorisation (Prajogo & Olhager, 2012; Singh & Power, 2014).

Some studies advocate a strong reliance on financial performance while others prefer operational performance. However, the strongest focus on operational SC performance is present in studies that value connectedness and relationships in the SCs, which is the perspective adopted in the present study in terms of prioritising performance goals (Ataseven & Nair, 2017; Cao & Zhang, 2011; Flynn et al., 2010). It is expected that operational goals will be prioritised over financial performance goals.

2.6.3 Supply chain performance contingent view

As mentioned earlier, the purpose of operations needs to be determined to understand how to evaluate the performance of those operations. Based on the goals identified, indicators are developed (Beamon, 1999). The purpose of SC operations in normal circumstances is not the same as under a natural disaster contingency. While operations of SCs under normal circumstances aim to maximise long-term profit and provide on-time and accurate delivery, in the face of natural disaster, SC managers may temporarily switch these goals with ones related to SCRES building.

Studies concerned with SCI influence on performance that considers some uncertainty, mostly look at operational performance with a focus on reaching timely delivery (Wong, Boon-itt, et al., 2011). However, DM literature specifies this even in early studies of catastrophes. Britt (1988) recognised that organisations facing a crisis aim to recover operations as soon as possible. Time of recovery is recognised as one of the crucial indicators of resilience in relation to natural disasters (Corey & Deitch, 2011). Guided by this understanding, Brandon-Jones et al. (2014) suggest that SCRES should be measured in terms of quick re-establishment of material flow and original conditions, and quick return to operational goals. While this study indicates there may be more to measure than only time needed to reach full capacity of operations, the issue exists because the multiple indicators suggested were not clearly explained or distinguished from one another. More recently, OSCM authors have adapted one of the indicators suggested in Brandon-Jones et al. (2014) and started measuring time needed to reach full operational capacity as a measure of SCRES (Van Den Adel et al., 2018).

Financial performance indicators are as contingent as operational indicators, but this nature has been overlooked in the OSCM literature. It is impossible to measure successful SCRES building in terms of financial performance indicators from normal circumstances. Therefore, OSCM research needs to focus on the identification of these indicators by according due attention to practice.

The current study seeks to address the gap in literature while identifying the main purpose and goals of SCRES building as a process taking place under natural disaster contingency. Based on these goals, SCRES measure indicators will be suggested based on the findings of this study.

2.7 Development of Research Questions

Based on the discussion presented above, this study has developed the following objectives:

Objective 1: determine how SCRES building works in practice and expand on existing SCRES models

Objective 2: identify and describe performance indicators of successful SCRES building as a process and provide guidance for developing a single, unique SCRES measure

Objective 3: clarify how SCI is utilised to support successful SCRES building and create a model that captures SCRES building, measurements insights and SCI that supports SCRES for future research.

Objective 1 is addressed by examining the four-stage model from the literature and building on it, resulting in a five-stage model of SCRES building. An additional two operations were detected, and one existing stage from the initial model was divided into two different stages based on data analysis. Objective 2 is addressed through identification of three different performance indicators. Objective 3 is addressed using the SCI structure that includes five SCI orientations (internal, supplier, buyer, government and community) and three SCI types within each SCI orientation (informational, operational and relational).

The study will examine the following research questions:

RQ1: How do SCRES building practices compare with the existing SCRES building model from the literature?

RQ2: What are the performance indicators of a successful SCRES building process that should be included in the measurement of SCRES?

RQ3: How is SCI utilised to support successful SCRES building?

2.8 Chapter Summary

This chapter has reviewed relevant literature for the present study, starting with structural contingency theory, to provide a foundation for the analysis that follows. It built on the discussion of SCs, SCM and SCRES, especially in the context of natural disasters, which were introduced as an environmental contingency. SCI was discussed in terms of its structure and potential to influence performance relating to SCRES against natural disasters. SC performance in existing research—with and without natural disaster as contingency—was considered. The literature review also identified motivation for the current research and brought OSCM literature and DM literature together.

The following chapter will present the research design and methodology. Philosophical assumptions are described at the beginning of the chapter, followed by research design describing multiple case studies. The multidisciplinary nature of resilience is discussed to clarify the meaning of the concept, followed by a presentation of the frameworks applied when collecting data related to SCRES building and SCI. The nature of the codebook utilised for data analysis is explained, and the validity and reliability of the method utilised is justified.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter discusses the study's research design and methodology. First, philosophical assumptions are described and then multiple case studies are discussed. The multidisciplinary nature of resilience is examined to clarify the concept, followed by a presentation of the frameworks applied during data collection on SCRES building and SCI. The codebook used in data analysis is explained, the process of thematic development is detailed and, finally, the validity and reliability of the method employed is justified according to Creswell (2013) and Yin (2009).

3.2 Philosophical Assumptions and Methodology

The discussion of the philosophical assumptions and methodology starts with an examination of the main paradigm applied in the present study. Positivism and interpretivism are discussed, and the application of phenomenological research in both cases. A multiple case study design is posited as an appropriate research method, and data collection methods are presented.

3.2.1 Philosophical assumptions

The positivist paradigm holds that there is one reality, and that reality is not a function of the researcher's interpretation or subjectivity (Collis & Hussey, 2014; Farquhar, 2012). It relies on the existence of one truth, which is the perspective adopted in this study. The study also relies on interpretivism by inductively capturing segments of frameworks that have not been previously identified in the literature. Sitting on the border of interpretivism and positivism, the present study aims to provide meaning that can indicate measurement insights but not to perform measurements itself.

When substantial research already exists on the phenomena of interest, a deduction is applied. If this is not the case, an inductive approach is employed when gathering and analysing data (Ambrosini et al., 2007). Farquhar (2012) suggests that employment of deduction and induction in the same study indicates that the investigation employs both positivist and interpretivist paradigms.

Collis and Hussey (2014) and Farquhar (2012) explain deduction and induction in research. Deduction starts from theoretical assumptions. The main concepts are captured from the literature, hypotheses or research questions are created, data collection is performed, and then research findings are induced from data analysis. Induction starts from data collection and analysis. It leads to recognition of patterns in the collected data and seeks to change existing theory or create a new theory.

Correspondingly, this study combines both approaches. Induction was utilised when patterns were recognised in the data generated by open-ended questions and open coding. Identification of these patterns led to modification of the SCRES framework extant in the literature. This process aided selection among the many SCI research frameworks relating to a particular contingency, and induced identification of an additional SC practice (trust) that proved relevant in answering the research questions.

The adapted SCRES and SCI frameworks were then utilised to analyse the entire data set. In accordance with Stake's (1995) explanation of the inductive pursuit, research questions were also refined after adaptation of the main frameworks to improve understanding of the phenomena. The interchange between deduction and induction in the current study is presented in Figure 3-1.

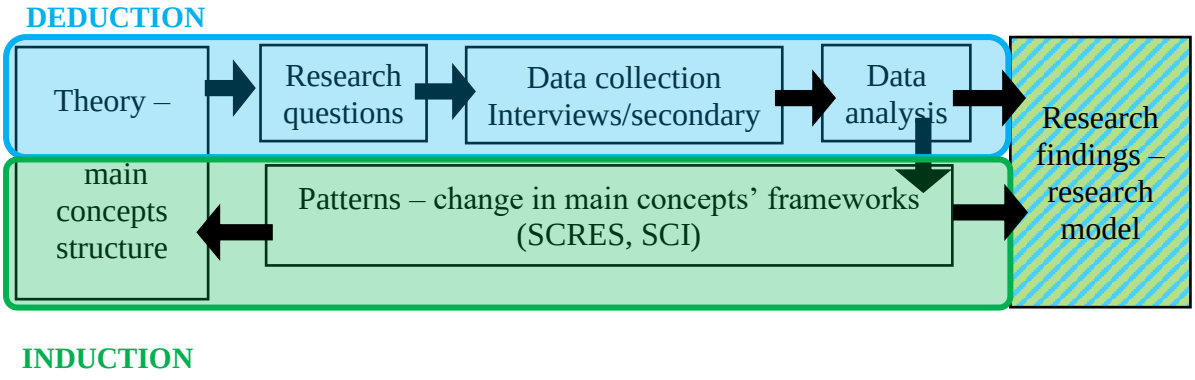


Figure 3-1*: The deductive and inductive approaches utilised in the research (adapted from Farquhar, 2012, p. 27)*

In the phenomenological research, participants describe lived experiences, which are utilised to build on existing knowledge of the phenomena (Van Manen, 1990). This aligns with the study's aim to improve current knowledge of SCRES in relation to natural disasters. Additionally, after collecting data, the phenomenological researcher develops a description and identifies codes that answer the questions 'what?' and 'how?' (Creswell, 2007).

Phenomenology does not identify different realities, but it recognises common truths between participants who have experienced the phenomena (Creswell, 2007), such as SCRES in relation to a natural disaster.

3.2.2 Research methodology

A multiple case study design was selected as the most appropriate approach due to the exploratory and descriptive nature of the study. The thesis provides descriptive insights on the nature of SCRES building and describes specific stages that unfold as the natural disaster impacts the SC. The study also provides exploratory insights on variation of SCI practices that have taken place during SCRES building and examines performance indicators that can identify what constitutes successful SCRES building. Following Stake's (1995) guidance, analysis was approached with a willingness to put any assumptions aside and explore the exact practices that took place to understand and describe them. Yin (2009, pp. 6–7) suggests that valuable propositions for analytical generalisability can be derived from exploratory and descriptive case studies, especially when replication in multiple case studies is engaged. Therefore, the present study not only describes the lived experience of a number of interviewees, it explores the phenomena of SCRES and SCI, and how SCI is adapted and utilised to support SCRES in diverse circumstances.

Eisenhardt (1989) explains that single case studies build an understanding of operations in a specific context. While this was an appropriate approach for initial research on SCRES relating to natural disasters, it has resulted in multiple frameworks generating outcomes that are not comparable. Conversely, the present study applies collective cases to provide comparable results that make possible analytical generalisability (Farquhar, 2012). Yin (2009) explains that multiple case studies can be developed by replicating single case study in a number of different contexts. This replication includes data analysis within all case studies against the same codes; that is, using the same framework for examining the main concepts. Relying on this observation, different contexts were developed in the present study by examining 13 different natural disasters. In total, 22 different SCs are examined. Each case SC and context were coded identically. Thus, the present study relies heavily on Yin's (2009) and Farquhar's (2012) guidance, whereby the unit of analysis in terms of methodology is the SC.

Direct interviews and secondary data were selected for data collection, as the literature suggests these methods are the most appropriate for positivist and interpretivist studies

(Bryman & Bell, 2011). The interview data is enriched by insights generated by the secondary materials.

3.3 Main Concepts and Frameworks

This section addresses the approach utilised to grasp different meanings of SCRES developed in various disciplines generally, and OSCM specifically. A discussion of the multidisciplinary nature of SCRES is followed by a description of the structure of the main concepts, SCRES and SCI.

3.3.1 Multidisciplinarity and resilience

The concept of resilience has been examined in multiple research areas, including disaster-emergency management, CM and RM studies. Notably, 'robustness' tends to be used interchangeably with the term 'resilience'. The existing body of research relating to natural disasters contingency commonly describes natural disasters by combining one or two descriptive words with one naming the disaster as disruption, hazard, crisis or similar (see Table 3-1, Column B).

***Table 3-1**: Terms used in the literature review process to identify literature related to resilience and natural disasters*

<table>
<tr><th colspan="4">Terms used in the literature to describe:</th></tr>
<tr><th rowspan="2">A) Resilience</th><th colspan="3">B) Natural disasters</th></tr>
<tr><th>B1</th><th>B2</th><th>B3</th></tr>
<tr><td>respond to</td><td rowspan="4">large scale</td><td>environmental</td><td>disaster</td></tr>
<tr><td>cope with</td><td rowspan="2">natural</td><td>disruption</td></tr>
<tr><td>bounce back (after)</td><td>hazard</td></tr>
<tr><td>recovering (after)</td><td rowspan="2">weather</td><td rowspan="2">crisis</td></tr>
<tr><td>preparation (for)</td><td rowspan="3">(none)</td></tr>
<tr><td>anticipation (of)</td><td>weather-related</td><td>threat</td></tr>
<tr><td>resilience to</td><td>(none)</td><td>risk</td></tr>
</table>

3.3.2 SCRES concept analysis framework

The first objective of this study is to improve understanding of SCRES and how existing frameworks match practitioners' insights. Existing OSCM literature recognises four stages of

SCRES building in relation to natural disasters (Scholten, Scott, & Fynes, 2014), as presented in **Table 3-2**.

***Table 3-2**: Initial SCRES model in table form (Scholten et al., 2014)*

SCRES stages	Operations of SCRES building stages
1. Preparation	☑Emergency team ☑ Preparation plan/existing stock
2. Initial Response	☑ Safety concerns and evacuation of people and property ☑ Implement response plan in terms of evaluating losses, direction and control
3. Recovery	☑ Implement recovery plan in terms of repair and rebuild ☑ Ensure continuity of management ☑ Resume/keep operations ☑ Full operations capacity reached
4. Mitigation	☑ Identify and implement improvements in preparation and other plans and procedures

The first is the preparation stage, which is conducted when a natural disaster is anticipated but is not expected to manifest any time soon. In this stage, plans are developed and an emergency team is identified. The second stage is the initial response, which starts when a natural disaster is certain and perceived to threaten the SC. In this stage, steps are taken to ensure safety and security before the crisis; subsequently, losses are evaluated, and plans for recovery are developed based on these evaluations. The third stage, recovery, entails managers taking relevant actions to return to full capacity of operations. Finally, the fourth stage, mitigation, begins when recovery is nearly complete or completed. In this stage, managers review the success of previous SCRES building and enrich existing SCRES building plans with insights generated from the review.

This study extends the existing four-stage SCRES model to a five-stage model that is considered a more appropriate method for examining SCRES building in relation to natural disasters (see Table 3-3).

Table 3-3: *Adapted SCRES model in table form (adapted from Scholten et al., 2014)*

SCRES stages	Operations of SCRES building stages
1. Preparation	☑Emergency team ☑ Preparation plan/existing stock ☑ Early Anticipation
2. Initial Response	☑Opportunistic Operations ☑ Safety concerns and evacuation of people and property ☑ Implement response plan in terms of evaluations of losses, direction and control
3. Reconstruction	☑Cleaning, repairing and rebuilding—preparing the entire site or part of it so operations, in any capacity, can be restarted
4. Recovery	☑ ~~Implementation of Recovery Plan in terms of Repair and rebuild~~ ☑ Resume/keep operations ☑ Full operations capacity reached
5. Mitigation	☑Identify and implement improvements in preparation and other plans and procedures

Note: Red = revised codes, Crossed-out text= separated as a new stage- Reconstruction

The adapted five-stage method of analysis recognises the third stage, reconstruction, as separate from the fourth stage, recovery. This facilitates capturing the effect of disaster just after its direct impact, which is crucial for SCRES building because SC managers invest significant resources into reconstructing the production environment prior to starting operations. In addition, two operations are recognised in the five-stage model that are not acknowledged in the existing literature: Early Anticipation in the preparation stage and Opportunistic Operations undertaken in the initial response stage.

The stages and operations presented in Table 3-3 are described further in the codebook, which is discussed in Section 3.5.2. The reasoning behind modifying the initial four-stage SCRES building model is explained in further detail in Chapter 5.

3.3.3 SCI framework

The variation of SCI orientation and type was examined as part of within-case analysis, while the scope of the SCI is examined in cross-case analysis. Within-case analysis of SCI orientation is considered in relation to the DAO, not the interviewee's company. Applying this principle to all cases enables multiple case studies to be comparable in accordance with the collective case study design.

The effect of a natural disaster on the examined SC was first visualised using structural representation, determining the position of the interviewee and the position of the DAO in the relevant SC. An interviewee may be employed in the DAO or in the DAO's supplier/buyer/T&L provider organisation. Once the interviewee's position in relation to the disaster is determined, this information was coded to facilitate analysis of SCI orientation. Therefore, the study findings present SCI orientation in terms of SCI between supplier and DAO as SCI with supplier, SCI between DAO and its buyer as SCI with a buyer, and so on. Additionally, internal SCI is captured for different organisations, most commonly for the interviewee's company, regardless of the disaster's effect.

Additional insights about relationships with the government and community are captured during different SCRES stages through analysis of the interviews and secondary data.

SCI was also examined to capture informational, operational and relational types within each SCI orientation. Interactions between two parties related to information and knowledge exchange are coded as informational SCI. Joining different teams in cooperation and collaboration is described as operational SCI, and building face-to-face relationships and bonding is coded as relational SCI. Further description of codes is presented in the codebook.

Variations of SCI orientation and type is captured in relation to the natural disaster's effect on the SC. As the SC goes through different stages of SCRES building, depending on the effect of the natural disaster, the approach taken seeks to apprehend SCI variations during the different SCRES building stages. This enables insights on how these variations are made to support different SCRES building stages (see Table 3-4).

***Table 3-4**: SCI structure in terms of orientation and type, coding structure approach*

SCRES stages	SCI orientation	SCI type
1. Preparation 2. Initial response 3. Reconstruction 4. Recovery 5. Mitigation	☑ Internal ☑ Supplier (between DAO and supplier) ☑ Buyer (between DAO and buyer) ☑ T&L provider (between DAO and provider) ☑ Government ☑ Community	☑informational ☑operational ☑relational

3.4 Data Collection

In addition to theoretical suitability, the present study considered the practical suitability of the data collection method. Relying on Yin's (2009) replication logic, the study captures rich descriptive content from managers about their experiences while facing natural disasters all around the world. Capturing this lived experience is enriched by qualitative and quantitative secondary data to improve understanding of SCRES building. Secondary data includes reports from media, government, scientific studies and company reports describing the nature and effect of the natural disaster in both qualitative and quantitative terms. Thus, secondary data is utilised to deepen understanding of the context and strengthen data validity, through the triangulation of sources and data collection methods, as suggested by Yin (2009) and Creswell (2009).

3.4.1 Case studies data collection method 1—Interviews

To capture as much data as possible about the concepts of interest when interviewing, the interviewing process was guided by a strict format. To grasp new notions and previously unidentified attributes of the concepts of interest, an open interview format was also engaged. Semi-structured interviews present an ideal tool to realise both these objectives. The semi-structured interview sits at the border of the structured and unstructured interview range; thus, it tolerates more flexibility than a structured interview while providing stronger guideline than an unstructured one (Tharenou et al., 2007). Flexibility in interviewing assists recognising any new constructs that might emerge and consequently contribute to the nomological network of resilience, while also identifying potential supporting practices in SCRES building.

Exploratory, semi-structured interviews were conducted to investigate SCRES building, performance indicators and SCI practice. As Kvale (1996) suggests, qualitative interviews should be about seeking kind, not degree, in relation to the issue at hand. Therefore, analysis seeks to grasp descriptions of existing stages and whether additional stages in SCRES emerge, evaluate SCRES performance and describe variations in SCI.

The main challenge in phenomenological interviewing is the need to gain a broad comprehension of the phenomena before conducting interviews (Creswell, 2013). This challenge is overcome by gaining a deep understanding of the broader body of literature relating to the SCRES phenomena (Lee, 1999). Drawing on this literature, interviewees were asked about their experiences while facing a natural disaster, the process of building SCRES and the approach to performance evaluation. They were also questioned about potential

challenges and supporting practices, as well as their additional insights on SCI gained in the process of SCRES building. Insights identified this way were used to adapt the SCRES building model selection of a relevant framework for examining SCI. This model and framework were then employed in the analysis of the entire data sample, relying on replication approach detailed by Yin (2009).

Demographics

Previous studies of SC disruption have found that SC managers are able to provide comprehensive insights about the experience (Flynn et al., 2010; Zhao, Huo, Flynn, et al., 2008; Zhao, Huo, Selen, & Yeung, 2011). In the current study, only SC managers who had faced natural disasters were interviewed. The location of the companies and natural disasters captured in the study sample is very broad to reflect the global meaning of SCRES.

The research targeted large firms with more than 100 employees; however, it was not intended that small companies would be excluded completely. One small firm that expressed interest in the research was included for the sake of comparison.

Large companies operating in the area affected by the natural disaster were contacted through Chambers of Commerce and the Supply Chain and Logistics Association of Australia (SCLAA). Further, the research was advertised on LinkedIn and open for SC managers to express interest in providing interviews. The majority of interviewees were recruited in this manner. The list of hurricanes, tornadoes, storms and cyclones was generated using data from the National Oceanic and Atmospheric Administration (NOAA) office for coastal management, using their online application system (NOAA, 2007). The Australian Government website for the Bureau of Meteorology (BOM) was used to gather additional data about storms that affected Australian territory (BOM, 2017a).

The search criteria utilised on LinkedIn to select interviewees included that they hold a SC management position in an Australia territory or currently live in Australia and have held a SC manager position in the past. More than 200 SC managers were identified using LinkedIn and an initial message explaining the study and requirements was sent. The initial message clarified that interviews were needed with individuals who had confronted natural disasters while holding a SC manager position in the last decade, but not during the past year, to ensure a fresh memory of the event while also allowing for some distance so the interviewee could generate insights relating to the firm's recovery process and status.

Polkinghorne (1989) suggests interviewing five to 25 individuals who have experienced the phenomena. In total, 25 managers agreed to meet or have telephone, Skype or Zoom interviews before saturation was reached. When saturation was reached, interviews were terminated (Hinkin, 1995; Lee, 1999). Four interviews were unsuccessful (indicated by 'x' in Table 3-5): one interviewee was uncomfortable discussing his experience, two interviewees were not directly involved in SCRES building, and one came from a consulting company and could only provide insights regarding the mitigation stage of SCRES building. All interviewees consented to interviews being recorded and transcribed for the purpose of the research.

Table 3-5: *Interview demographics and natural disasters—contexts*

No.	Interviewee position	Industry	Interviewing technique	Age Group (years)
1	National BDM in SC	Automotive	Face-to-face	50–55
2	SC manager	Construction	Telephone	40–45
3	SC director	Food	Skype audio call	45–50
4	Head of SC	Food (dairy)	Telephone	35–40
5	Group SC manager	Agricultural	Telephone	55–60
6	Purchasing officer	Automotive	Telephone	45–50
7	Head of logistics	White goods	Telephone	45–50
8	General manager of SC	Furniture	Telephone	40–45
9	SC manager	Food	Telephone	35–40
10	SC manager	White goods	Telephone	50–55
11	Continuous improvement SC manager	Retail	Face-to-face	40–45
12	SC operations manager	Automotive	Telephone	45–50
13	Network planning manager for a distribution company	Courier T&L	Telephone	30–35
14	Supply officer	Mining	Telephone	55–60
15	Logistic manager	Perishable retail	Telephone	40–45
16	International SC manager	Perishable retail	Zoom video call	35–40
17	Site and operations manager	Healthcare	Telephone	50–55
18	Continuous improvement SC manager	Automotive	Telephone	45–50
19	Head of SC	Mining	Face-to-face	40–45
20	National operations and SC manager	Agricultural	Telephone	30–35
21	SC manager	Courier T&L	Face-to-face	25–30
x	Operations manager	Food	Telephone	30–35
x	SC and logistic consultant	–	Face-to-face	25–30
x	Operations officer	T&L	Face-to-face	20–25
x	General manager	Agricultural	Zoom video call	30–35
22	CEO	Retail	Exegesis	55–60

All participants were male, currently holding middle or senior management positions. Further demographics of the study sample are presented in Table 3-5. Interviews provided for media and reports developed by the CEO of Metcash were collected and coded as an interview to learn about SCRES building in this company.

Interview protocol

Lee (1999) was followed to form the main themes before interviews were conducted. Thematising was performed in writing and discussed with peers before the interviews. Subject boundaries and freedom of conversation flow, as well as the aims of the interview, were explained to the interviewees in the invitation letter (provided in Appendix A). Further, interviewees were supplied with an interview agenda, and notified that the process was debriefed upon conclusion and notes and recordings were made during the process.

Kvale's (1996, pp. 133–135) process was used to construct the interview protocol. This process generated 35 questions; however, allowances were made to utilise these flexibly if deemed necessary during the interviewing process. The protocol was developed to address the replicative nature of the multiple case study approach, following Yin (2009) (see Table 3-6). All interviews were conducted and transcribed in the period 21 August–26 October 2017. Out of the 25 interviews conducted, 21 were considered complete and adequate.

***Table 3-6**: Interview protocol*

Interview protocol					
Interview number					(number)
Name and Last Name				Age	(age group)
Contact information	Telephone number	+614	☐	Preferred contact	
	Email	example@gmail.com	☐		
Current position and company	SC manager at ABC Ltd. (example)				
Position and company in the time of the disaster described	SC manager at CBA Ltd. (example)		Industry	Mining (example)	
Date and time of the interview	Date:	dd/mm/yyyy	Time:	hh:mm	
Location of the interview	Address / Skype / Zoom/ telephone call				
Duration of the interview	hh:mm:ss				
Interview transcribed	Y / N				

The literature suggested the researcher should draft notes with key ideas captured within one hour of completing each interview (Stake, 1995). When needed, additional notes were subsequently prepared to record all insights provided and improve the quality of the planned thematisation process that followed. Interview questions are presented in Table 3-7.

***Table 3-7**: Interview questions and related topics*

Interview questions		
1. Explaining event (description of anticipation and reaction)		
Can you tell me more about natural disaster you or your SC member have faced?		
1.1	Has that event affected your facility or your supplier or buyer?	
1.2	When did the event happen (approximate month and year, or how long ago)?	
1.3	How often does it happen at that location? Was it completely unpredicted?	
1.4	How long before the event happened you were aware it would affect your location?	
1.5	How did you find out the event was going to affect you?	
2. Explanation of event effect (consequences' severity and scope)		
Did affected companies stop operations because of the extreme weather event? If yes, for how long?		
2.1	What was the effect of natural disaster on organisations in your SC?	
3. Describe SCRES building (steps conducted)		
Can you describe the entire process from the time you heard about disaster approaching to the end?		
3.1	What did the organisation in your SC do in terms of preparation?	
3.2	What were the actions conducted when you knew the disaster would affect you? (elaborate)	
3.3	What has been done after that? (follow-up questions until full recovery or mitigation is reached)	
3.4	Have you implemented any lessons learned or improved existing plans after the event?	
4.5.	When did you consider being recovered?	
4. Describe performance indicators		
How did you grasp learning from the process? How did you evaluate the success of conducting SCRES building? (questions below asked only if not described in answers on questions above)		
4.1	How long did it take for the affected company to start operating again?	
4.2	How long did it take to gain 100% of regular operations capacity?	
4.3	Which sector of the SC was most affected by event and how?	
5. Explaining SCI		
5.1 How integrated are your sectors inside your company?		
	5.1.a	How was internal SCI utilised to support SCRES building? (If not described within the description of each stage)
	5.1.b	Can you describe this in more details? (purpose is to capture the type of SCI)
	5.1.c	How important was internal integration for resilience?
5.2 How integrated are you with your buyer?		
	5.2.a	How was buyer SCI utilised to support SCRES building? (If not described within the description of each stage)
	5.2.b	Can you describe this in more details? (purpose is to capture the type of SCI)
	5.2.c	How important was that integration for resilience?

Interview Questions (continued)		
5.3 How integrated are you with your supplier?		
	5.3.a	How was supplier SCI utilised to support SCRES building? (If not described within the description of each stage)
	5.3.b	Can you describe this in more details? (purpose is to capture the type of SCI) (This description also serves to distinguish a good supplier from T&L supplier if not previously distinguished in the discussion)
	5.3.c	How important was that integration for resilience?
5.4 Have you had any interaction with the government or community? (question asked after revision)		
	5.4.a	How was SCI with government and community utilised to support SCRES building? (If not described within the description of each stage)
	5.4.b	Can you describe this in more details? (purpose is to capture the type of SCI)
	5.4.c	How important was that integration for resilience?
6. Additional insights		
What is the lesson learned or is there something you would like to add that hasn't been discussed?		
7. Important resilience enhancers identification		
What would you say is the most important for resilience? (or for successfully overcoming the crisis)		
Try to elaborate on the reason of such importance.		
Total	**The total duration of all interviews**	**The average duration of one interview**
35+	**12 hours, 15 minutes**	**Approx. 35 minutes**

3.4.2 Case studies data collection method 2—Secondary data

Prior to conducting each interview, secondary background information regarding the firms affected and the disaster was garnered. Following the completion of the interview, this process was extended to triangulate and confirm the validity of the account. Secondary data was coded for descriptions of the nature and effect of the natural disaster and the firm's response. Moreover, secondary data was utilised to improve understating of the effect and response of other firms in the same location and industry to compare their experience with the case SC. Secondary data included:

- government reports from a range of departments, press releases, senate discussions, and reports by emergency relief organisations and public scientific organisations (such as Commonwealth of Australia, US government, local municipalities reports, BOM, NOAA, National Hurricane Centre [NHC], Government of Hong Kong [GovHK])
- private company reports that are part of the SC affected by the natural disaster (such as Metcash)

- private companies' reports that are not part of the affected SC but were indirectly involved in addressing the natural disaster (such as Insurance Council Australia [ICA])
- published research papers from academic journals, as well as research published in the form of audio or audio-visual material (such as documentary movies)
- newspaper articles and reports at the time of the disaster and following the disaster from leading newspapers (such as the *Washington Post*, *Sydney Morning Herald* and *New York Times*)
- media coverage, audio-visual material and reports from global and local news corporations (such as Sky News, ABC, Seven News, SBS, CNN, Reuters and similar).

All documents were publicly available. Table 3-8 lists a number of different sources of secondary data examined for the 13 different contexts of natural disasters. The table also presents a number of direct interviews captured in the secondary data. Audio-visual material and news articles were captured jointly under 'news' and the complete list of documents examined in the study is provided in Appendix B of this thesis.

Table 3-8: *Secondary data sources per different natural disaster context*

No.	Natural disaster	Governmental reports and press releases	News—printed media and recorded video and audio	Companies' reports	Published research	Interviews captured in all secondary data
1	Queensland floods (2008)	15	10	/	3	24
2	Tropical cyclone Tasha (2010)	17	16	/	1	25
3	Hurricane Sandy (2012)	12	31	/	1	37
4	Tropical cyclone Lua (2012)	6	19	/	/	23
5	Tropical cyclone Marcia (2015)	7	20	3	2	32
6	Flood in Western Australia (2017)	8	11	/	/	25
7	Tropical cyclone Debbie (2017)	6	40	1	2	~1,250
8	Typhoon Soudelor (2015)	9	26	3	3	6
9	Pacific Ocean typhoon season (2013)	16	1	1	1	/
10	Anzac Day hailstorm (2015)	1	12	4	/	13
11	Millennium drought and flood (2010)	15	9	/	7	9
12	Eyjafjallajökull eruption (2010)	/	11	/	12	10
13	Tohoku earthquake and tsunami (2011)	5	26		2	34
	Total	**117**	**232**	**12**	**34**	**~1,488**

3.5 Data Analysis

The purpose of phenomenological research is to improve understanding of the phenomena and grasp its meaning, which is invariably multi-layered (Van Manen, 1990). Collective case study design enables employment of an inductive-deductive approach and replication. This means patterns (i.e., frameworks) utilised in the initial data collection inductively lead to changes in existing frameworks. After the frameworks were adapted, they were employed in the analysis of the entire data sample. Therefore, the present study applied a two-layered analysis technique, as suggested by Yin (2009) and applied by Fayezi et al. (2015). The first layer formed boundaries and prioritised what to analyse. This resulted in modification of the framework of SCRES and selection of an appropriate framework to examine SCI. This model and framework provided a foundation for the second layer of analysis, which resulted in findings segmented in three groups that correlate to the three research questions.

The study applied thematisation in coding both the primary and secondary data. This analysis resulted in a deeper understanding of cases with within-case analysis focusing on each case separately (Eisenhardt, 1989), and aggregated understanding of all cases in cross-case analysis (Yin, 2009). To enable comparison and aggregated understanding, a single framework of SCRES building and same SCI framework were employed in each within-case analysis. Further, to examine SCI, DAO was placed as a focal company in the relationships rather than the interviewee's organisation or manufacturer. Thus, maximal potential of collective case study design was captured, as multiple cases are comparable and analytical generalisability is reached, enabling collective findings (Yin, 2009).

The present study utilised the enterprise as the level that describes SCRES building in the entire SC. It is possible to evaluate SCRES using the description provided from one node in the SC because resilience on one level of the enterprise leads to resilience on higher levels, as in cases when positive practices are transferred in the SC (Van der Vegt et al., 2015).

Analysis of different contexts and case SCs are presented separately in the following sections. First, analysis of the contexts (i.e., natural disasters) examined are discussed. Then, case SCs analysis is reviewed, including case SCs' SCRES building in response to effects of natural disasters and SCI practices adapted to support that SCRES building.

3.5.1 Contexts—Natural disaster analysis

The present study examined 13 different contexts corresponding to 13 different natural disasters that occurred in the last decade. In accordance with contingency theory applied in this study, each environmental contingency (i.e., natural disaster) needed to be described and understood to comprehend the process of SCRES building engaged against that natural disaster. Case SCs needed to maintain and recover their operations within this environment, utilise SCI to support those operations and measure the success achieved in building resilience against the natural disaster. However, before discussing the SCRES and SCI analysis further, the context must be elucidated.

To understand each context, secondary data was coded using a specific, dedicated codebook (see Table 3-9). Moreover, secondary data was the only data used in the analysis of one case SC, SC-A1, while all other cases included data from direct interviews. Analysis of this case SC is described in Section 3.5.2, which addresses the analysis of all SCs and their responses.

As presented in Table 3-9, natural disasters were coded into two major themes: nature and effect. Relying on the contingent nature of the study, the effect of the natural disaster was included to ensure a robust understanding of the severity and scope of the impact on the case SCs. The first and second sections of Table 3-9 were used to code secondary data before interviews were conducted, while the third section was employed after each interview.

***Table 3-9**: Codebook for secondary data in relation to context understanding*

Codebook for secondary data		
1. Main information about the disaster and its nature		
Name of the natural disaster:		
Nature of the disaster (or type):		
☑ Tropical cyclone, ☑ Hurricane, ☑ Flood, ☑ Earthquake, ☑ Tsunami, ☑ Volcanic eruption, ☑ Drought, ☑ Typhoon, ☑ Hailstorm		
Year and/or date of occurrence:	dd/mm/yyyy	
Disaster duration:	(days)	
Disaster intensity:	(category of a cyclone, magnitude of earthquake…)	
Frequency of occurrence	☐ Seasonal	☐ Non-seasonal
2. Overall effect		
Prolonged effects of disaster:		(landslides, floods, etc.)
Duration of the prolonged effect:		(days before flood withdrawal)
Total area affected by natural disaster and prolonged effects:		(square kilometres, number of local governments, or similar)
Overall financial effect of the disaster:		(damage caused)
Overall effect in terms of infrastructure:		(roads, rail, air and sea transport, utilities, communication network)
Overall effect on businesses:		(financial and operational means)
Affected industry:		(list of industries affected)
Severity of the effect on industries :		(financial and operational means)
3. Effect on examined case SCs		
Location or area where case SCs were affected:		(sourced from interviews)
Effects of disaster and its prolonged effect on the location where case SCs were affected:		(operational and financial means)
Industry(ies) case SCs operate in:		(sourced from interviews)
Effect of the disaster on the industry(ies) case SCs operate in:		(operational and financial means)

Table 3-10 presents additional codes for the contexts of the natural disasters that were captured only after the interviews were completed.

After natural disaster descriptions were developed, additional maps showing the effects of natural disasters were generated. The maps detail the effect on SCs from the same industry and in the same area that case SCs were affected. Each natural disaster was examined in terms of at least one case SC.

***Table 3-10**: Additional codes in relation to natural disaster and its effect*

Theme		RQs	Subthemes and descriptions
Natural disaster	Position of direct effect	2,3	☑ Direct This code is captured in the description of the effect of the natural disaster on the case SC, especially the effect on the interviewee's company. Where interviewee's company has property or operations directly affected by a natural disaster, the effect position is coded 'direct'. This includes descriptions of inundated facilities; damaged roofs; majority of supplies damaged or significantly delayed in transit from supplier but under ownership and responsibility of interviewee's company; damaged vehicles, equipment or tools; and main facility tightly surrounded by flood that disables any operations and requires cleaning of surroundings. ☑ Indirect In cases where interviewees described only a transfer of direct effects on their organisation, it was coded 'indirect'. This means the organisation that supplies the interviewee's company or buys from the interviewee's company has been directly affected. For example, if the supplier was affected by a storm and had a significant amount of goods at the location damaged, which caused delays in delivery of crucial supply to the interviewee's company, but the interviewee's company was not affected by storm or flood at all. This effect would be coded as direct if supplies damaged were already in transit to reach the interviewee's company, therefore under their ownership.
	Direction of transfer of indirect effect	2,3	The direction of transfer of indirect effect in the SC was coded according to indirect effects transferred form DAO in one SC to other companies in the SC. ☑ Upstream Upstream effect transfer was captured from DAO towards the beginning of the SC; that is, towards second-tier supplier. ☑ Downstream Downstream effect transfer was captured from DAO towards the end of the supply chain; that is, towards customer.
	Prediction of natural disaster		Inductive approach to code generation led to the creation of two codes relating to prediction of the natural disaster's direct effect, where natural disasters that directly affect the SC were predicted over five days in advance were coded as 'predicted'. Those that were expected to affect the SC with short notice or no warning were coded as 'unpredicted'. This created two separate codes: The five days' timeframe was inductively captured as a condition of additional action that took place during the initial response SCRES building stage and presented as part of the discussion of results in this thesis. ☑ Predicted and ☑ Non-predicted.

3.5.2 Analysis of the case SCs and their response

When some ambiguity or inconsistency about relatively established theories and frameworks exists, then data collection that builds on those frameworks might be too extensive (Miles & Huberman, 1994). Miles and Huberman (1994) suggest reduction and clarification to solve this issue. Accordingly, semi-structured interviews were applied in the current study to gather comprehensive and substantial data, in terms of quantity and quality, while also limiting data collection to a manageable form.

After the interviews were completed, they were transcribed and analysed using the thematisation process in Excel and NVivo software. Tables were generated for an overview of all examined SCs. Themes were listed in tables and, following an inductive process, the codebook was developed further. Separate Excel sheets were generated for SCRES building, SCRES performance indicators, and SCI.

Themes cannot be simply discovered by word detection software (Van Manen, 1990). The researcher must focus on the meaning the research participants sought to communicate. After going back and forth between the literature and transcripts, and in accordance with the template analysis approach, a review of the statements coded as 'additional insights' enabled adaptation of the SCRES and SCI framework. Thus, new themes emerged, which resulted in amendments to the SCRES building model and additional SCI orientations and SCI types, as well as three different SCRES building performance goals. The codebook was updated to address this development.

Second-line coding was performed in NVivo software three months after coding in Excel, which ensured higher validity. As Kvale (1996) asserts, qualitative research mostly focuses on differentiation and identification of the phenomena of interest. The present study used this approach while identifying and distinguishing different stages of SCRES building and different operations within these stages, as well as different SCI orientations and types.

As previously noted, a total of 22 SCs were examined within 13 different natural disaster contexts. Each within-case analysis included a description of the natural disaster first, and then a description of SCs affected by that natural disaster, SCRES building and SCI. The final version of the codebook applied in the analysis is presented in Table 3-11. The research findings are presented separately for within-case analysis in Chapter 4 and aggregated cross-case analysis in Chapter 5.

Table 3-11: *Main codes for analysis of SCRES building stages and SCI practices that took place during SCRES building stage*

Theme		RQs	Subthemes and descriptions
Supply chain resilience (SCRES)	Stage 1: Preparation	1	☑Emergency team This code is captured when the interviewee describes identified emergency team members or another action that mentions an emergency team, such as 'crisis team', 'disaster management team' or any other team in charge of emergency-related action management and decision-making during emergency. ☑ Preparation plan This code is captured when the interviewee describes any type of preparation plans, including relevant stock policy intended for any disruption, safety and emergency evacuation plans, disaster management plan, or any other plan that indicates the organisation has invested time and effort in thinking about preparing for a natural disaster and produced written rules on its management. ☑ Early anticipation This code was captured when the interviewee witnessed building additional stocks solely to buffer the effect of an anticipated natural disaster. This stock exists to address natural disaster caused deficit in supplies, and redundancy is built on top of regular redundancy to any disruption.
	Stage 2: Initial response	1	☑ Opportunistic Operations This code was captured when interviewees witnessed opportunistic production and/or shipping in the face of the natural disaster. It includes description of operations a few days before the direct effect of natural disaster, after disaster approaching is announced but before safety warning are announced. ☑ Safety concerns and evacuation including people and property This code is captured when there was an indication of evacuation; safety concerns for employees and goods, vehicles and facilities; elevation of products in storage spaces; or assuring continuous supply of electricity for goods that need refrigeration. ☑ Implement response plan in terms of evaluations of losses, direction and control This code is captured in a description of financial evaluation of losses that occurred as a consequence of the natural disaster after safety warnings are lifted. The code also captures work on the planning and organising cleaning activities, and creating a plan of actions to help the affected site reach an operational state.

Theme		RQs	Subthemes and descriptions
Supply chain resilience (SCRES)	Stage 3: Reconstruction	1	☑ Cleaning, repairing and rebuilding—preparing the entire site or part of it to be able to restart operations in any capacity at all This code is captured in the description of cleaning the affected site, rebuilding damaged buildings, and repairing or buying spare equipment, vehicles or tools. All these actions were done to prepare the site to resume operations in any capacity. In addition, this code might be captured when new temporary locations are prepared to resume operations until the original, directly affected location has been recovered.
	Stage 4: Recovery	1	☑ Resume/keep operations This code is captured in the description of restarting operations in any capacity when a production company starts producing again or a service-providing organisation starts providing services. For organisations that did not have interrupted operations, this means they continued operations in an alternative manner or reduced capacity. ☑ Full operations capacity reached This code is captured when full operations of the organisation and SC are reached, including returning to the operational capacity that existed before the natural disaster affected the SC, and regular or improved operations.
	Stage 4: Mitigation	1	☑ Identification and implementation of improvements in preparation and other plans and procedures This code is captured in descriptions of learning-related activities that indicate revision of actions taken in the previous stages of SCRES building, including identification of possible improvement points in the existing plans now tested against natural disasters.
	SCRES additional stages	1	This code is captured when interviewees spoke about a specific set of actions separate from descriptions of the existing stages, especially if they started emphasising one set of actions distinct from the rest of the actions as part of one of the SCRES building stages. Those actions then formed a separate SCRES building stage, which allowed adjustments of the existing SCRES building model in terms of number of stages. Revised codes are presented in red in Table 3–3.

Theme		**RQs**	**Subthemes and descriptions**
Supply chain resilience (SCRES)	SCRES building performance goals	2	This code is captured in descriptions of SCRES related goals, where interviewees provide some insights by suggesting how the organisation and SC measured their success in SCRES building or evaluated the success of SCRES building as a process within mitigation stage, for example. The code was revised after re-reading interviews in the three codes presented below.
			REVISED CODES:
			☑ Time needed to restart any operations OR minimisation of it This code was inductively captured when the interviewee described the outcome of the SCRES building stages, especially the reconstruction stage, as time the organisation and SC needed to reach any operations at all in cases where operations stopped. A shorter time indicated more successful SCRES building.
			☑ Time needed to reach full capacity of operations OR minimisation of it This code was inductively captured when the interviewee described the outcome of the SCRES building stages, especially recovery stage, as time the organisation and SC needed to reach full recovery (100% of capacity). A shorter time indicated a more successful SCRES building process.
			☑ Financial losses OR minimisation of them This code was inductively captured when the interviewee described the outcome of the SCRES building stages in terms of concerns for financial losses due to the natural disaster. Smaller losses indicated a more successful SCRES building process.

Theme		RQs	Subthemes and descriptions
Supply chain integration (SCI)	SCI type	3	☑ Informational This code was captured in a description of integrative activities that include communication or information exchange. In the description, the interviewee might describe 'talking', 'communicating' or 'speaking', or describe communication with examples such as 'I called … then they said … after that we notified … then they explained'. ☑ Operational This code was captured in a description of integrative activities that include the organisation and effort of teams from multiple parties, as well as additional tangible and intangible resources invested in supporting SCRES building. Interviewee descriptions under this code might include 'cooperation', 'collaboration', 'delayed paying conditions', 'production alterations', 'additional services provision' and 'teams coming together'. ☑ Relational This code was captured in a description of integrative activities that include bonding between people. Interviewee descriptions that might be captured by this code include descriptions of social connections, such as 'trust', 'understanding', 'common values', 'integrity', 'openness and honesty', 'mutual care'; and repetition of words that indicate close relationships, such as 'honest, very honest communication' and 'very, very close cooperation'.
	SCI orientation: Supplier	3	As part of the SCI orientation with a supplier, all relevant descriptions of integrative activities that support SCRES building, including specific interactions between the DAO and its supplier, are captured under this code. The code is captured in relation to DAOs, meaning the interviewee was able to describe SCI with supplier from the supplier's position (in the case they are suppliers of DAO) or the DAO's position (in the case they are DAO). The code is additionally distinguished in the three SCI types described above, creating three codes: ☑ Informational SCI with supplier, ☑ Operational SCI with supplier, and ☑ Relational SCI with supplier.
	SCI orientation: T&L supplier	3	As part of the SCI orientation with a T&L supplier, all relevant descriptions of integrative activities taken to support SCRES building, including specific interactions between the DAO and its T&L supplier, are captured under this code. The code is captured in relation to DAO, meaning the interviewee was able to describe SCI with T&L supplier from the T&L supplier's position (in the case they are T&L suppliers of DAO) or the DAO's position (in the case they are DAO). The code is additionally distinguished in the three SCI types described above, creating three codes: ☑ Informational SCI with T&L supplier, ☑ Operational SCI with T&L supplier, and ☑ Relational SCI with T&L supplier.

Theme		RQs	Subthemes and descriptions
Supply chain integration (SCI)	SCI orientation: Buyer	3	As part of the SCI orientation with a buyer, all relevant descriptions of integrative activities that support SCRES building, including specific interactions between the DAO and its buyer, are captured under this code. The code is captured in relation to DAO, meaning the interviewee was able to describe SCI with buyer from the buyer's position (in the case they are buyers of DAO) or the DAO's position (in the case they are DAO). The code is additionally distinguished in the three SCI types described above, creating three codes: ☑ Informational SCI with a buyer, ☑ Operational SCI with buyer, and ☑ Relational SCI with buyer.
	SCI orientation: Internal	3	As part of the internal SCI orientation, all relevant descriptions of integrative activities that support SCRES building, including specific interactions between sectors, teams and employees in one organisation, are captured with this code. This also means internal interactions were mainly described for the DAO from the position of the DAO who is also the interviewee, but also in some cases where the interviewee had insights and was able to describe internal SCI in a DAO from a supplier's or buyer's perspective. The code is additionally distinguished in the three SCI types described above, creating three codes: ☑ Informational internal SCI, ☑ Operational internal SCI, and ☑ Relational internal SCI.
	SCI orientation: Non-commercial	3	This code was captured in descriptions of interactions between companies from affected SCs and additional, non-commercial stakeholders, such as community and government, that support SCRES building. As with previous codes, the code was divided as follows: ☑ Informational SCI with government, ☑ Operational SCI with government, and ☑ Relational SCI with government. ☑ Informational SCI with community, ☑ Operational SCI with community, and ☑ Relational SCI with community.

3.6 Validity and Reliability of the Multiple Case Study Research Design

In the present study, validity and reliability are considered during different research stages, from data collection to data organisation and analysis.

Reliability of the transcription process is ensured by using transcription services outsourced to the third party and comparing these with manually created notes (Lee, 1999). The validity of this process was also considered. Alterations to the meaning of what the interviewee was trying to communicate were minimised by the researcher summarising the interview once it was complete. Further, the exact word order and shape of the statements provided in the analysis were followed. Follow-up emails and calls were conducted when further clarification was needed from the interviewees.

To ensure the validity and reliability of the data collected during direct interviews, Creswell (2013) suggests employing at least two validation procedures. In the present study, all interviews were transcribed and enriched with notes, thereby increasing transferability. The initial set of questions included both structured and open-ended questions. Open-ended questions were followed-up with additional questions when elaboration or confirmation of meaning was needed. Additional sources, such as publicly accessible web sites of the companies and interviewees' LinkedIn profiles, were used to compare information and increase validity and reliability (Yin, 2009).

Additional elaboration on the research validity and reliability for the study is provided in Table 3-12, adapted from Yin (2009), Creswell (2013) and Bals and Tate (2018).

A chain of evidence was collected for analysis of each of the 13 natural disaster contexts. This evidence commenced when the disaster first occurred—usually spotted by weather agencies or scientific bodies—to its development and eventual termination. The description of the disaster's nature was built on with key evidence about disaster's effect from emergency services, natural resources agencies, governmental bodies on relief and recovery funds, and audio-visual and printed material form broadcasting agencies. Within each context, additional attention was dedicated to finding a chain of evidence on the effects of a disaster on the corresponding case SCs' industry and the area affected. For this purpose, maps of a disaster's effects were created. Further, the chain of evidence continued when analysing each case SC and their response in terms of SCRES and SCI employed to build SCRES. Reports from interviewees' companies were located and cross-examined, and descriptions of affected infrastructure sourced from governmental maps and reports.

Table 3-12: *Validity and reliability of the research*

Criteria	Application in the study
Construct validity	Triangulation—multiple evidence sources included; for example public information (web sites, Linked In profiles), notes and interviews Chain of evidence is established in the case of natural disaster descriptions and SC response descriptions
Truth value	Member checks—review of interviewee data, confirmation of comprehended answers
Transferability	Purposive sampling to ensure valuable insights on resilience relating to the natural disaster contingency are captured
	Coverage of different industries (mining, transport, food, furniture)
	Coverage of different roles in the model SC (second-tier supplier, first-tier supplier, manufacturer, wholesaler, retailer, transporter)
	Coverage of different roles relating to position of direct effect in the SC (DAO, supplier of DAO, buyer of DAO, T&L supplier of DAO)
	Reflection on specific context—resilience in relation to natural disasters during the interpretation of preliminary results
	All interviews were transcribed and enriched by notes
	All secondary data was collected and organised per specific context—a natural disaster
Traceability	Common interview protocol applied in all interviews
	Database structured in 13 different contexts to simplify an overview of natural disasters and their effect in relation to examined SCs, as well as related evidence sources
	Database structured in the form of 22 different groups to keep an overview of 22 different SCs and related evidence sources

Yin (2009, p. 58) asserts that 'the typical criteria regarding sample size … are irrelevant' and suggests focusing on detecting the phenomena the study aims to capture, and ensuring variety within that phenomena. In this study, variety is ensured first, through data collection—documents examined from various sources—and second, by including multiple contexts in the form 13 different natural disasters that occurred globally. This provided sufficient context variety, as the contingent environmental approach adopted in this study recognises natural

disaster generally as an environmental contingency. In this approach, time of occurrence, type of natural disaster, location of natural disaster and its effects vary significantly from one context to another. At the end of the data analysis phase of the research, findings are compared. The application of replication suggested by Yin (2009) make this possible. Data reliability was confirmed in the results relating to interviews, as the findings from analysing one SC compared to another did not depend on or vary based on the time, place or nature of the natural disaster.

The codebooks presented in the previous section of this chapter provide a comprehensive overview of the codes, main themes and subthemes in relation to all research questions. This increases transferability and provides better insights into the validity of the study. In terms of external validity, Yin (2009) suggests that the collective design of multiple case studies that include replication can bring theoretical and analytical generalisation; however, generalisation cannot be assumed based on one context. Only when findings match in several different contexts is there strong support for building on existing theory. Therefore, in the present study, multiple data sources were employed to understand each context, and each of the 13 contexts was examined against the same framework to address the replication approach. As findings did not depend on context or data source, external validity is ensured.

The final goal of reliability, minimisation of biases, is often addressed by careful explanation of the data collection process and organisation. This is important so future studies deploying the same procedures draw the same findings. Thus, data collection has been explained in detail in the above sections, and all data collected during the study carefully organised according to the natural disaster it describes and the case SCs it refers to, as described in Table 3-12.

3.7 Chapter Summary

This chapter discussed the philosophical assumptions and research methodology applied in the present study. Main concepts were defined and structured, data collection and data analysis methods presented, and validity and reliability justified.

Chapter 4 will address the findings of the within-case analysis. It presents research findings across the 13 different natural disaster contexts and 22 different SCs that were building SCRES within these contexts.

CHAPTER 4: FINDINGS OF WITHIN-CASE ANALYSIS

4.1 Introduction

The findings of this research are presented over two chapters: Chapter 4 addresses within-case analysis and Chapter 5 addresses cross-case analysis. In this chapter, the effects natural disasters have on SCs globally is depicted in accordance with Stake (1995). Then, 13 different contexts corresponding to 13 natural disasters are explained, and SCs' responses to them presented to focus discussion on SCRES. Each case begins by describing a natural disaster that took place in the last 10 years, drawing on secondary data, and is followed by the corresponding interviewee's description of the disaster's effects. Each natural disaster context contains experiences described in direct interviews with at least one SC manager from one SC, and up to four SCs that were impacted by the disaster.

Secondary data examined included a range of publicly available documents and additional insights regarding the impact of the disaster on the specific location and industry in which the SC is situated. In total, 21 direct interviews with SC managers were analysed and one SC response was generated by secondary data analytics. Each case is introduced with an explanation and visual representation of the SC structure and the effect of the disaster on that SC. The position from which the interviewee perceives the SC is shaded blue colour (see Figure 4-1), and the effect of the natural disaster on that SC is marked in red.

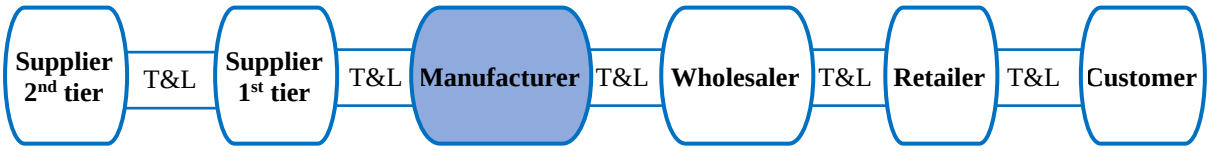


***Figure 4-1**: Model schematic representation of the case SC with interviewee's organisation position indicated*

The effect of the disaster on the SC is distinguished in terms of direct and indirect effect, where direct impact appears on the schematic presentation as a red square, shading the proportion of the SC that was directly affected. The direction and reach of the indirect effect are indicated with a red arrow (see Figure 4-2). The direct effect included the impact of the disaster and its prolonged effects on the specific location. This may include strong winds that damaged roofs or utilities or flooded nearby areas that inundated the facility or isolated significant amounts of cargo.

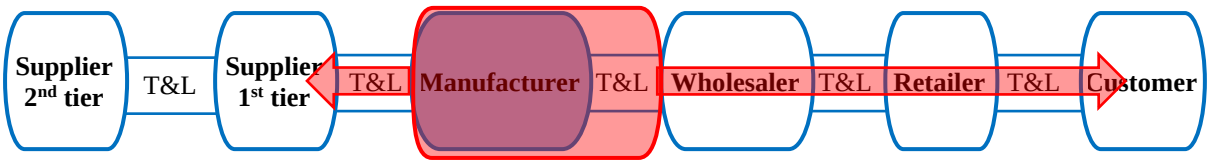


***Figure 4-2**: Complete model of a schematic representation of the case SCs and natural disaster effect on them*

In the example provided in Figure 4-2, the indirect effect of the disaster was transferred from the DAO (i.e., manufacturer) to the first-tier supplier upstream and from the DAO and T&L supplier between manufacturer and wholesaler, downstream, where it impacted customers. Schematic presentations were crucial to deepen understanding of the SCRES building stages as well as relationships in the SC. Schematic presentations of the case SCs revealed insights in each case on the SCRES building process and SCI practices that were altered to support stage completion.

To enhance understanding of the SCI practices that took place between different stakeholders and to enable comparison and analytical generalisation, SCI practices were analysed in relation to the DAO; that is, SCI with supplier (SCI between DAO and supplier), SCI with buyer (SCI between DAO and its buyer), and so on. SCI types are described as Informational, Operational or Relational and added to the SCI orientation description, resulting in Informational SCI with a buyer or Informational Internal SCI, for example.

4.2 Global Influence of Natural Disasters on SCs

The area affected by natural disasters is growing and the financial damage they cause businesses is increasing (Ronnenberg et al., 2017). The first two decades of the 21st century saw an increase of 151% in financial losses caused by natural disasters on the last two decades of the 20th century, globally (Wallemacq & House, 2018). Moreover, 21st-century natural disasters are recognised as being less predictive and more difficult to manage because of cascading and prolonged effects (Corey & Deitch, 2011; Lawther, 2016; Van der Vegt et al., 2015). For example, in the last two decades, earthquakes have wiped out 17.5% of the national GDP of Haiti, 4.2% of GDP in El Salvador and 3.5% of GDP in Georgia. Storms have cost Korea 7.4%, Cuba 4.6% and Nicaragua 3.6% of GDP (Wallemacq & House, 2018). In the last decade in the US, damage caused by natural disasters has been five times greater than in the 1980s (UNISDR, 2015). Natural disasters cost the Australian economy AUD18.2 billion annually on average, which represents 1.2% of GDP (IAG, 2017). This cost is expected to double by 2040 (IAG, 2017; Ronnenberg et al., 2017), and global annual losses as a result of

natural disasters are expected to reach AUD568 billion for infrastructure investments only (RBA, 2019 [exchange rate, December 2015], UNISDR, 2015).

Natural disasters are affecting SCs all over the world. For example, the Tohoku earthquake and tsunami severely disrupted the global automotive industry in 2011 (Matsuo, 2015) and induced estimated losses of AUD282.5 billion (RBA, 2019 [exchange rate, date of source publication]), making it the costliest natural disaster recorded to date (Wallemacq & House, 2018). Superstorm Sandy caused breakdowns of infrastructure in multiple countries and disrupted major shipping lines operating in the North Atlantic Ocean and Caribbean Sea in 2012, with AUD72 billion of economic damage (RBA, 2018 [exchange rate, November 2012]; Sales & Knight, 2012; WEF, 2015). In Australia, tropical cyclone Debbie disrupted agriculture and the national coal industry in 2017, inducing billions of dollars' damage (IGEM, 2017). With natural disasters affecting organisations all over the world, resilience towards natural disasters has become an urgent research subject (Van der Vegt et al., 2015).

4.3 Case Studies on Natural Disasters' Impact—Data Analysis

4.3.1 Queensland floods (2008)

Between 14 and 15 February 2008, extreme rainfall beset the city of Mackay in North Queensland, Australia. Mackay was immediately flooded and declared a disaster zone (Hall & Watson, 2008; O'Connor, 2008). While the BOM issued warnings, the rainfall was three to six times greater than predicted (Hall & Watson, 2008), so most local businesses, households and emergency services were completely unprepared (Hall & Watson, 2008). The amount of rainfall became calibration data for future flood management studies and infrastructure in Queensland (Doyle, 2018).

Thousands of properties lost power and were not reconnected for two weeks; mobile telecommunication was disrupted and only limited texting was possible; landline communication was severed; Mackay airport was closed; and the local road network, including the main highway, was closed and badly damaged, as was rail infrastructure (Apan et al., 2010; Hall & Watson, 2008). Floodwater reached window levels and water quality became unsafe as sewage water had breached and crocodiles were spotted in the water (Apan et al., 2010).

Government reports and scientific studies published after the event reported that 10% of Mackay city households were inundated and 97% of businesses in Mackay had floodwater inside business premises (Apan et al., 2010; BOM, 2008; Doyle, 2018). Mackay businesses

reported significant losses, measured in tens of millions of dollars, mostly caused by lost stock in perishable industries. An extended period without operations occurred because infrastructure took a long time to recover, so restocking businesses was hindered. Some businesses even reported losing customers because competition managed to recover faster (Hicks, 2008).

BOM issued a cancellation of weather warnings on 28 February 2008, two weeks after the initial downpour, and the Minister of Emergency Services announced that 26 local government areas besides Mackay were severely impacted (Apan et al., 2010).

The 2008 Queensland floods affected many SCs, including mining SC-Q1 and perishable retail SC-Q2, which are examined in this study. The author has developed maps (see Figure 4-3 and Figure **4-4**) to depict the influence of the Queensland floods on these industries (adapted from BOM, 2008; Department of Infrastructure, Regional Development and Cities [DIRDC], 2015; Queensland Government Statistician's Office [QGSO], 2012; Geoscience-Australia, 2015).

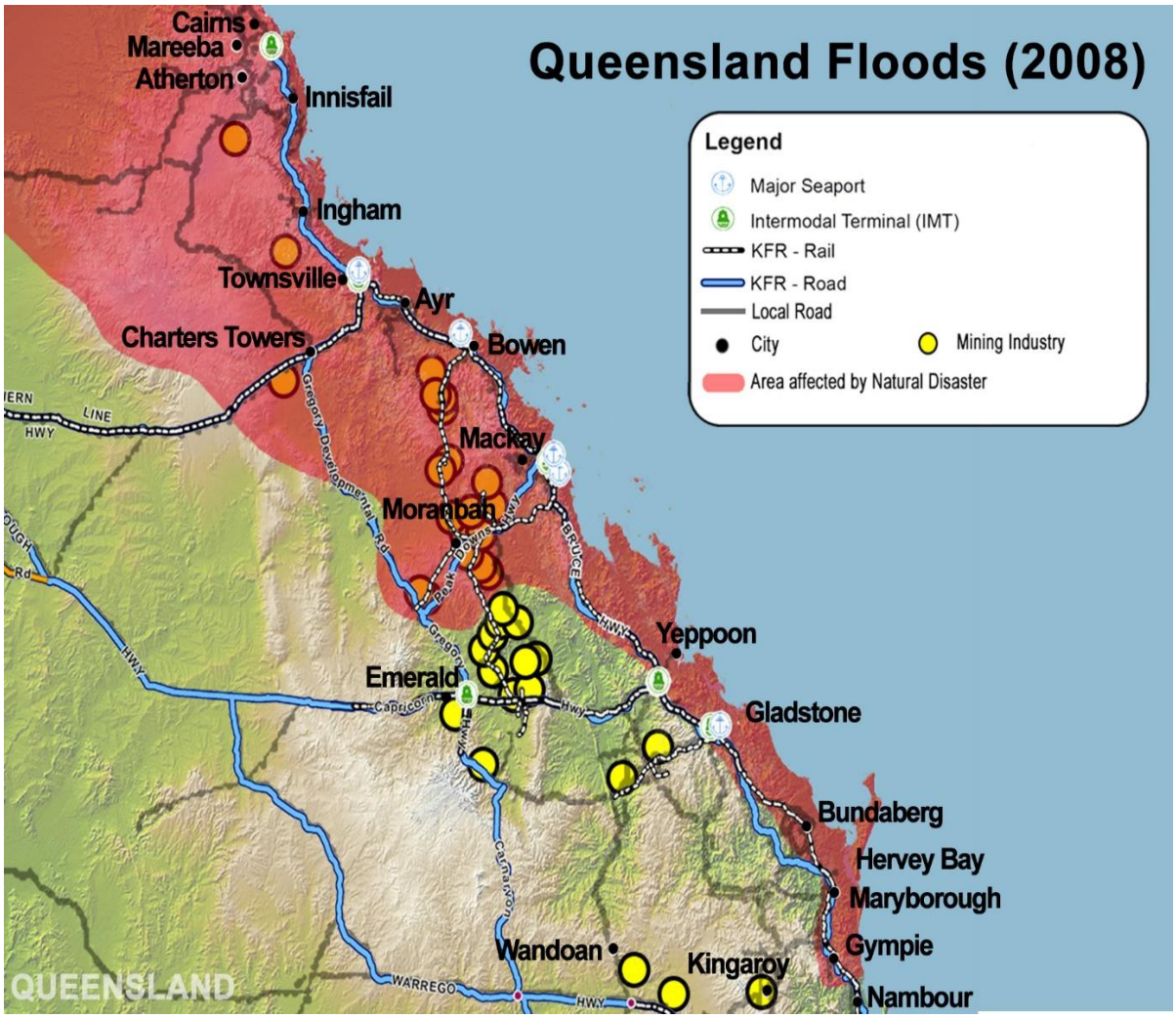


***Figure 4-3**: Influence of 2008 Queensland floods on mining SCs*

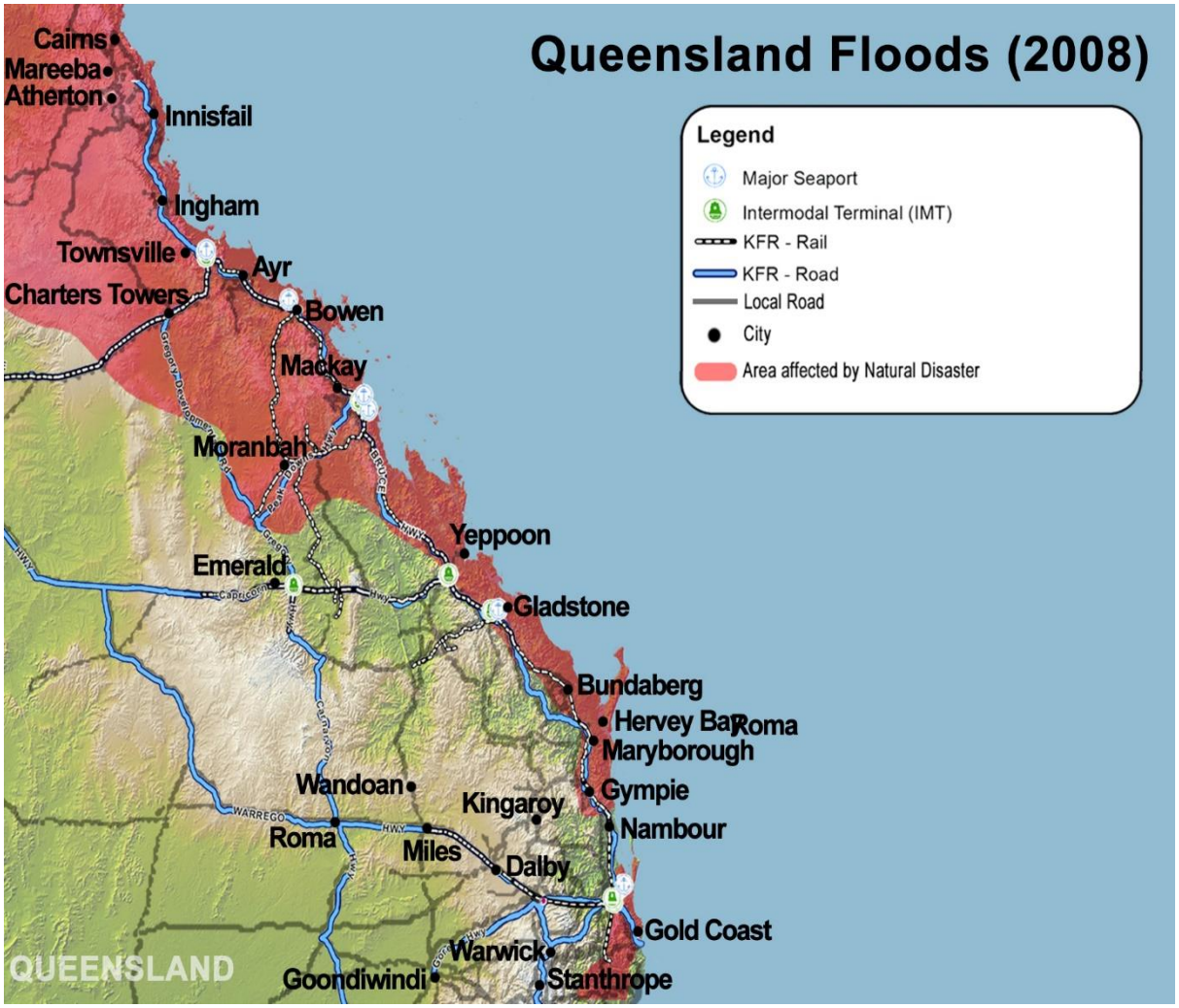


***Figure 4-4**: Influence of 2008 Queensland floods on retail SCs*

Queensland floods 1—Mining SC-Q1

In the mining SC-Q1 the interviewee witnessed the event from the position of a second-tier supplier whose firm's facilities were directly affected by rainfall and flash flooding. This resulted in a complete halt of operations for four weeks and full recovery was not achieved until four months later, causing a reduction in annual production of 20%.

The interviewee explained that his entire supply source was severed, as his suppliers were also flooded, and cargo was trapped in transit. Since the interviewees' company (i.e., the DAO) wanted to restart operations as quickly as possible, multiple attempts were made to find alternative sources of supply to fill the most urgent orders from buyers.

The DAO was surrounded by floodwater, but this remained a limited problem because the roads were cleared before the firm was ready to restart operations. The first-tier supplier and the T&L linking the DAO and first-tier supplier was indirectly affected. There was no effect recorded further downstream in this SC (see Figure 4-5).

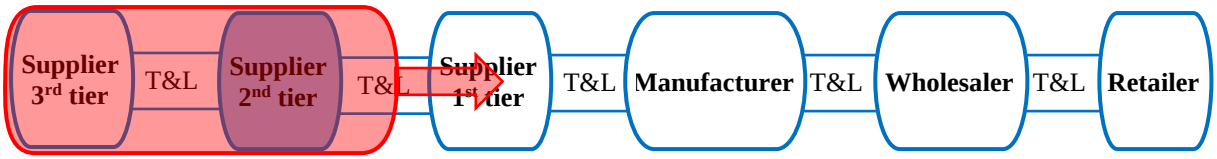


***Figure 4-5**: Graphical representation SC-Q1 and effect of natural disaster on it*

The interviewee emphasised that on their own, preparation plans are not enough to build resilience, and relationships are a crucial part of resilience:

> *I didn't have security for the fire mart, I had things like building up trust between the supplier and ourselves, building up a good relationship between us.*

The crisis was completely unpredicted as the DAO did not expect the rain to reach their location—'*It just wouldn't normally happen'*. Immediately after realising that water levels were getting dangerously high, the DAO engaged safety measures—*'Safety is number one'*—and debated where they needed to cease operations—'*Now, initially, we didn't realise there was that amount of water'.* Production had to stop—'*The actual mining itself we stopped for two weeks'*—and alternative plans for recovery were created. The interviewee described this as part of the discussion of Informational Internal SCI in terms of communication upwards between the local SC manager and top management, whereby local management was expected to create solutions for SCRES building. The interviewee also mentioned that a two-sided conversation with governmental organisations helped to coordinate their activities during the *Initial Response* stage.

The interviewee then described cleaning the site and trying to re-establish operations. He explained that production capacity varied significantly during the *Recovery* stage. After partial production was restarted, challenges related to a lack of stock emerged, so they decided to cooperate with competitors to recover faster and reach full operation capacity sooner:

> *So, we were in a situation where we had the capacity, but we did not have the ore. We just spoke to them and said, look, we've got capacity, do you want to do a tall milling operation? ... We'll pick up your material, we'll take it to the concentrator, we'll process it for you for the cost of some structure, which gives us a proper margin of so and so.*

The interviewee explained that they used this approach to generate income to enable them to reach full capacity of operations faster and advised that internal SCI, and integration with suppliers and with buyers, accelerated the *Recovery* stage.

The interviewee described utilisation of both Informational and Operational Internal SCI during the *Recovery* stage:

> *Look, one sector manager would say I've spoken to [Interviewee's name], and we've gone to our inventory to gain an understanding of our situation. We advised that every department had keep on working and determine what we can get around.*

He also emphasised the importance of internal relationships during the *Recovery* stage:

> *I advised my staff, you know, don't look at the paper. Here, take my hands. We work together, we find solutions together. That human relationship and understanding is valued.*

Informational and Relational SCI with suppliers were deemed important to SCRES during the *Recovery* stage. Informational SCI with suppliers was mostly described as communication in terms of ensuring stocks and fostering understanding in the relationship:

> *I had things like building up trust between the supplier and ourselves, building up a good relationship between us. That was my main reasoning for the ensuring there was a robust reserve of consignment stock.*

However, the interviewee also explained that buying a significant body of stock from a supplier and letting the latter know you intend to continue this practice builds trust in itself, and this trust increases the likelihood that your needs will be prioritised in a time of crisis:

> *If you maintain a high level of consignment stock, basically you're building up a much higher level of trust between a supplier and yourself.*

The Interviewee stressed the importance of the transparency that can be generated by Informational SCI with buyers during the *Recovery* stage:

> *Just getting back to those buyers like I said … getting them involved in seeing what's going on is of importance.*

The *Mitigation* stage was explained in terms of the DAO continuously looking for better recovery plans and ways to address risk generally:

> *We're always looking to improve, but we're also always looking at what the alternatives are. What are the risks involved in the alternatives?*

Queensland floods 2—Retail perishable and non-perishable SC-Q2

Perishable retail SC-Q2 is described from the perspective of a SC manager employed by a wholesale company. Customers and the T&L company that transports cargo downstream from the wholesaler were directly affected by the flood. At the same time, the wholesaler and retailers were indirectly affected; one by an upstream effect, and one by both an upstream and downstream effect. Ten of the retailer's stores were unable to access basic utilities, such as electricity, but were able to continue partial operations by selling non-perishable goods.

Product that required cooling and ventilation were disposed of. The interviewee advised that the flood's effect did not extend further upstream in this SC-Q2 (see Figure 4-6).

Since wholesaler and retailer are under the same ownership and the wholesaler ships to one retailer exclusively, the wholesale organisation was analysed as an indirectly affected entity and supplier of directly affected customers. T&L companies operating between wholesaler and retailer were deemed directly affected, as railroads were severed.

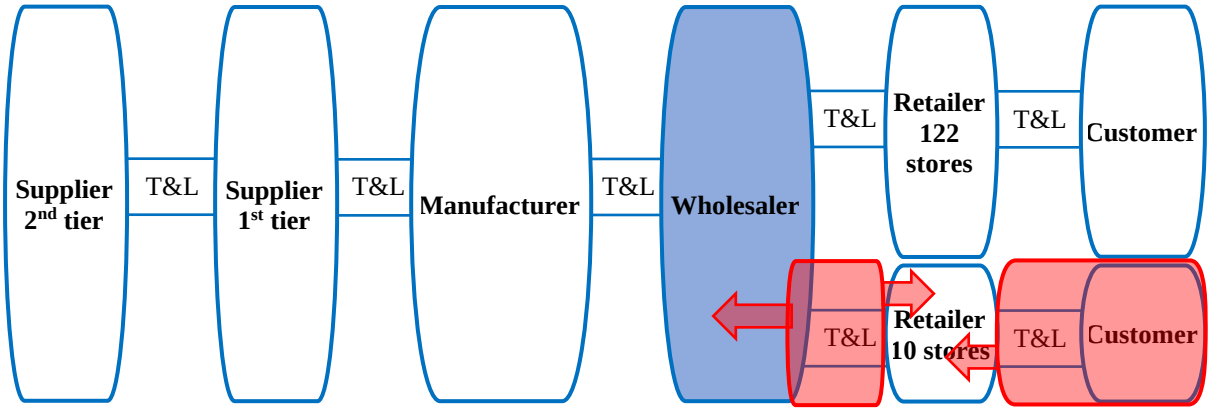


***Figure 4-6**: Graphical representation SC-Q2 and effect of natural disaster on it*

Financial losses were experienced by the wholesale company as it had to pay for more expensive road transport instead of rail, and road transport prices increased twice immediately after safety warnings were lifted. However, the wholesaler decided to utilise road transport to supply stores with cut utilities as soon as roads were opened, despite the increased cost. The wholesaler did not have trouble supporting 122 other stores and losses generated in the 10 affected stores were significant but marginal.

As part of the *Preparation* stage and other stages discussed, the interviewee mentioned they had emergency plans and teams in place. He explained that they expected and were prepared to deal with floods, as they had previously experienced similar events. Moreover, they were warned five days in advance that heavy rain and a possible flood was approaching some of their stores and advised that this was normal—'*You generally had four or five days advanced warning'*. Based on this, the *Initial Response* stage started with opportunistic shipping of goods that were marked as potentially being in high demand by stores:

> *So you'd be trying to get a load of bottled water, candles, matches, lighters, that sort of stuff, because generally power would go out, so they were looking for lighting and drinking water.*

Safety measures were applied in the affected locations, and after the event was over, evaluation of what needed to be done to restore full operations was undertaken:

> *Was the road open, was the rail open? We'd pick orders and get it on the road and get it as far as we possibly could and have it wait until conditions improved ... It could be that it sits on a road that's been closed, it could sit there for a couple of days until the road was opened so we could push it forward.*

This description includes Operational and Informational SCI with the T&L supplier, as close cooperation and coordination was needed to organise trucks to ship as far as possible and then wait for the road to open to be the first in the market to reach the store with stocks:

> *This entailed sitting down with transport companies and working out how we could get through or go around to get into those towns.*

Internal Informational SCI during the *Initial Response* stage was described as entailing communication about goods that were urgently needed in directly affected locations, and that these would be sent as soon as safety warnings were lifted—'*The orders were placed by the stores. So, we would get a heads up'.* In addition, the interviewee described Informational and Operational Internal SCI involved in opportunistic shipping, explaining that by mobilising the emergency team and teams working together, they could opportunistically ship as many emergency goods as possible to the stores that were expected to be affected.

The interviewee described Informational SCI with buyers in terms of communication with direct customers, but the discussion was more oriented towards care for the community, with no specific concern over whether buyers would remain loyal in the future—*You need to make sure local families have basic needs. They need it*.

The interviewee advised that they were regularly tracking the BOM phone application and making sure everyone was aware of the state of the weather. This was deemed crucial for opportunistic shipping, which they believed gave them an advantage in the market. In addition, communication with governmental organisations was judged as important throughout the *Initial Response* stage because these agencies provided estimations on which transport infrastructure was going to be available, which enabled them to coordinate their transport and accelerate the re-establishment of regular operations.

The *Reconstruction* stage did not occur as there was no damage to existing facilities. By contrast, the *Recovery* stage entailed filling the shelves and delivering supplies to the affected stores as soon as the roads made this possible:

> *Once we were able to do anything with those stores, we had to drop everything else and get cracking on those stores and get the goods to them.*

The interviewee described Internal Informational SCI as communication downwards in the organisation between the executives managing the emergency team and employees:

> *Communicate. If you think you're a good communicator beforehand, be a better communicator during that process. The more people that understand what's going on and what you're trying to achieve, the better.*

Communication between different departments of the organisation was also underscored:

> *We would be talking to the supermarket management team because it was silos and the logistics department was a silo and the supermarkets were a silo and they needed to be brought together.*

The interviewee elaborated on Internal Operational SCI in relation to the organisation's departments needing to be coordinated and advised that their previous experience had taught them the importance of effective coordination for fast recovery—*At that stage, we were more experienced as a team on the day-to-day stuff as we'd handled a number of these crises.* He further described Relational Internal SCI in terms of relationships between departments in the organisation:

> *Having experienced a number of these events, there was a level of trust that was built between the supermarkets and the distribution centre. So, some of these events helped build that trust because they and the store's emergency team could see the prior work we had done to in order to provide them with the best service we possibly could.*

The interviewee described Informational, Operational and Relational SCI with the T&L supplier as very important during the *Recovery* stage. First, he described open communication:

> *There has been a bit of a history of being a little bit secretive within the business that involved not telling the transport company too much, no telling the supermarket customers too much. Now it is accepted that in crisis situations, there's no such thing as too much, tell them everything they need to know. Normally we have meetings on a daily basis with our transport companies but during the crisis we were meeting probably three times a day.*

Then he explained that Informational SCI supported Relational SCI with T&L suppliers. This occurs through frank communication that supports the development of closer relationships, which can be utilised to support Operational SCI. As a result, the T&L provider chose to prioritise the interviewee's company over other firms that required transport during the crisis:

> *We were talking so intimately with them, so regularly with them during that period of time, it helped the relationship … each of us could see that the other was working really hard to accommodate a common goal of being the first into the town.*

The interviewee also observed that Operational SCI existed with the T&L provider and governmental agencies, which made it possible to accelerate the restoration of operations:

> *There were times I worked with transport companies to use government fire trucks to get into towns that had been isolated. If the road wasn't available.*

On discussing the *Mitigation* stage, the interviewee observed that this was improved via closer coordination of the staff within the interviewee's company and creation of new plans by learning from the experience. This stage relied on good communication and knowledge sharing among employees.

4.3.2 Tropical cyclone Tasha (2010)

Tropical Cyclone (TC) Tasha beset Queensland on Christmas Eve and Christmas Day 2010. It made landfall near Cairns, about 1,400 km from Brisbane and dissipated just two days later, 600 km southwest of the landfall location. Although TC Tasha lasted only two days and the strength did not breach the category one limit, it drew monsoon-like La Niña clouds towards Queensland and created a disaster zone across 78% of the state. Even when it began to weaken, TC Tasha collided with two additional cloud systems, bringing more rain to Queensland (Queensland Government, 2015), which caused floods that did not withdraw until 17 January 2011 (National response to the floods, 2011; Whiting, 2010).

TC Tasha killed 35 people and 42 out of 77 local government districts suffered its direct effect, including shore, central areas and Southeast Queensland (Queensland Government, 2015). Due to the severe flooding, roads and bridges were damaged and thousands of properties inundated (Whiting, 2010). The roads remained severed for three weeks (Van De Wetering, 2011; Woods, 2011). Ferry terminals in Brisbane destroyed by this disaster were not operational until March 2015 (Caroll, 2015), and most areas of Brisbane were inundated and without power (Doyle, 2011).

Retailers from Bundaberg and Rockhampton suffered severe damage due to the water level rising too fast to elevate stock in time, therefore causing significant inventory losses (Whiting, 2010). Supermarkets started running out of stock (Cummis, 2010) and a large fleet of trucks was utilised to carry necessities as close as possible to endangered areas ('Heartbreaking' floods to cost billions, 2010). Towns in the Bundaberg region were evacuated, flood water completely covered Bundaberg bridges, and the entire agricultural area of Banana shire was completely flooded and isolated (Calligeros, 2010).

TC Tasha disrupted 25% of businesses in Queensland and 10% of businesses nationwide. Agricultural losses were significant and authorities expected over a billion dollars in lost revenue (ABARES, 2011); 75% of banana crops were destroyed (Whiting, 2010) and banana prices increased some 500%; macadamia, avocado and sugar cane crops were damaged and tomato SCs from the Bundaberg region were severely disrupted due to the Burnett River breaching ('Heartbreaking' floods to cost billions, 2010); and dairy producers all over Queensland were forced to dispose of dairy products (ABARES, 2011; Fraser & Owens, 2011). The dairy industry in Australia had no growth in revenue during 2010, and only 0.4% growth in 2011 and 1.5% in 2012. The literature does not identify a specific reason for this; however, as major dairy exporters were affected in TC Tasha, it can be concluded that part of the reason for the stagnation of revenue in 2010 was the natural disaster.

SCs examined within this context are agricultural SC-T1, dairy SC-T2, white goods SC-T3 and T&L currier SC-T4. Again, the author has developed maps (see Figure 4-7, Figure **4-8** and Figure **4-9**) to represent the affect TC Tasha had on these industries (adapted from BOM, 2011; DIRDC, 2015; PwC, 2011; QGSO, 2012).

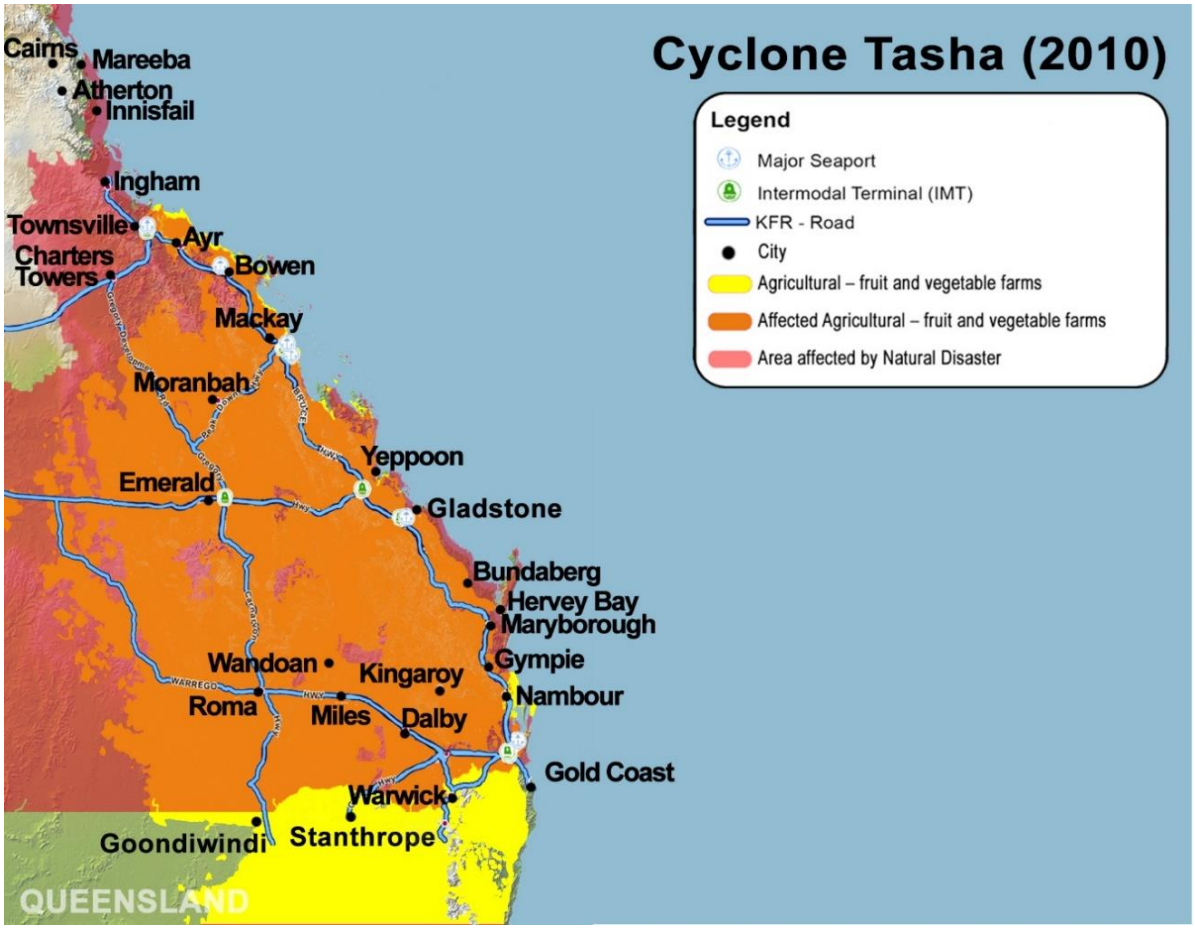


***Figure 4-7**: Influence of TC Tasha and floods on agricultural SCs*

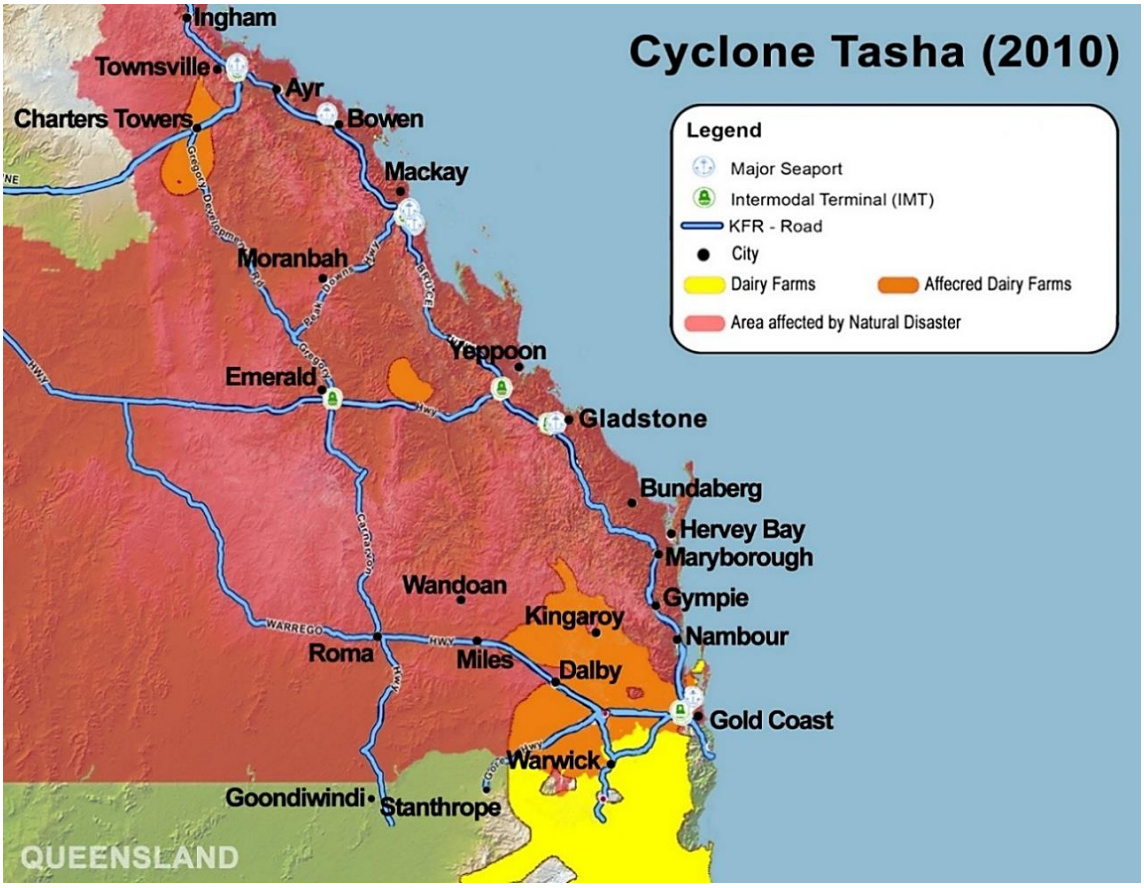


***Figure 4-8**: Influence of TC Tasha and floods on dairy SCs*

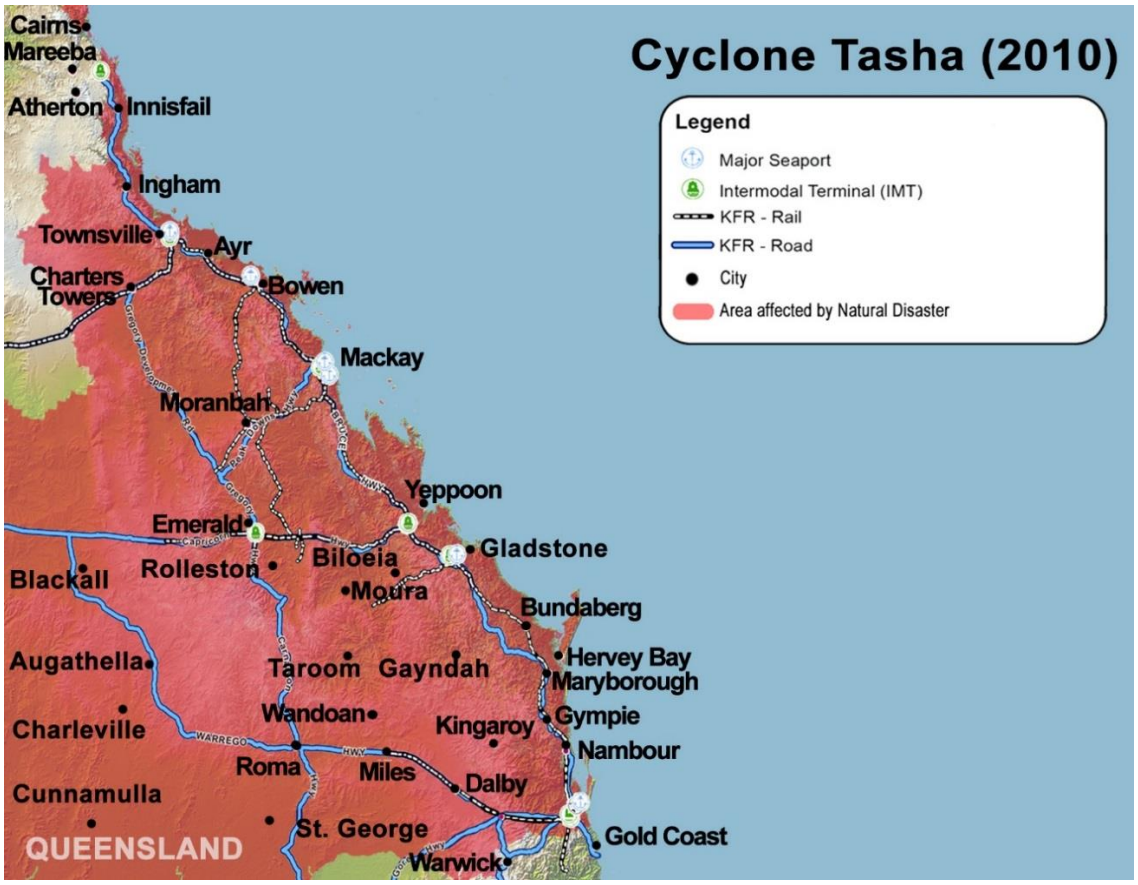


***Figure 4-9**: Influence of TC Tasha and floods on white goods and T&L SCs*

TC Tasha 1—Agricultural SC-T1

Agricultural SC-T1 is described from the perspective of a first-tier supplier who owns farms in the central Burnett region near Bundaberg, and Cairns, which experienced flooding and imposed severe losses on local farmers and retailers.

The first-tier supplier had crops and farms directly affected by winds and floods; therefore, this company is analysed as a DAO. The firm lost over AUD 40 million and needed four years to fully recover. Upstream effects on second-tier suppliers manifest because the DAO had reduced buying power for a prolonged time; manufacturers were affected directly and indirectly, in terms of lack of supply product available to buy (fresh fruit and vegetables) and inundated properties for some manufacturers. Consequently, retailers were not able to buy enough product to put on the shelves, and the wide scope of the damage even affected customers due to significant rises in the prices of fruit and vegetables (see Figure 4-10).

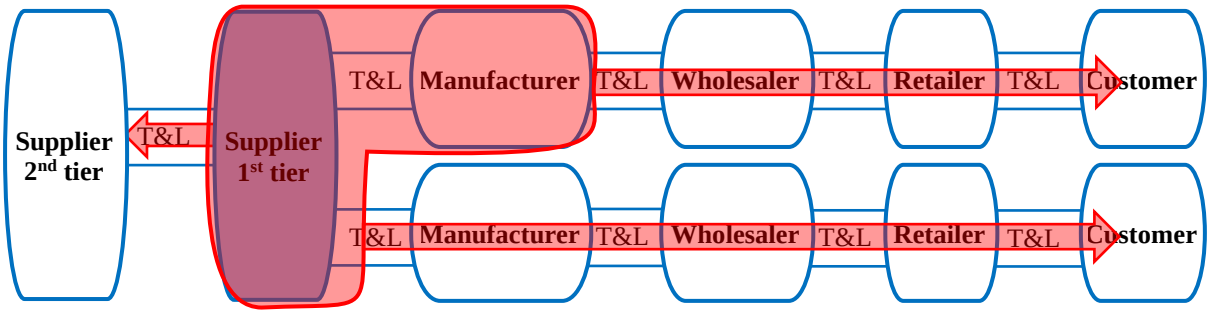


***Figure 4-10**: Graphical representation SC-T1 and the effect of natural disaster on it*

The interviewee observed in relation to the *Preparation* stage, that they had plans and an emergency team in place—'*We have a list what we need to do ... we have a team doing it.*' The interviewee was aware that excessive rain might affect them a few weeks in advance and based on that decided to operate opportunistically:

> *We knew we would have excessive rain, but at the same time, we also knew that we could harvest as a substantial amount of crop before it was damaged.*

When TC Tasha approached and floodwaters started filling the fields at the interviewee's location, safety measures were applied—'*The first reaction always is the safety of the people'*. After safety warnings were lifted, the DAO started evaluating the damage—'*find a count for the damage in monetary terms'*—and determining how to recover from the disaster. Questions addressed included:

> *How many years will it take for the soil to recover?… What do we need to do to make sure recovery will happen? ... What does that mean for future years, how long will it take for normality to return?*

During the *Initial Response* stage, the interviewee described Informational and Relational Internal SCI as communication inside the company and care for employees, calling employees '*my people'*. He jointly captured the *Initial Response* and *Recovery* stage when describing communication importance, while relying on Informational Internal SCI in terms of communication downwards:

> *I think again, coming back to the basic underlying thing, which is good communications with employees.*

Informational SCI with buyers and suppliers and other stakeholders was important from the beginning of the effect until full recovery:

> *I think communication is the key with everyone. The sooner you communicate with relevant stakeholders, the better.*

Interactions with the government was important in terms of following the guidance of weather agencies to make decisions about Opportunistic Operations.

Discussion of the *Reconstruction* stage included recovery of vehicles from the mud and cleaning the flooded fields and facilities. The interviewee described Informational and Operational Internal SCI that remained important until complete recovery, and observed that increased effort from employees was supported by social bonding and management's appreciation of their hard work:

> *They were sometimes distressed at the amount of effort that they had to put in ... But having said that, if you appreciate the efforts, that definitely helps to motivate employees.*

The importance of relationships and mutual understanding was emphasised once again while explaining that building these relationships before any effect of natural disaster serves to support increased effort during SCRES building:

> *You do the best you can during good times because difficult times are not far away … you have to be able to be honest and humble during your wins.*

He made clear that communication aimed to create strong relationships and social bonding:

> *Employees are part of the process. They are part of the journey, as well.*

Informational SCI was also developed jointly with supplier, buyers and other stakeholders:

> *The whole process is ongoing and it's very hard to say when you give your feedback because you start giving feedback as soon as you are aware of it and you can account for it.*

The interviewee particularly emphasised the importance of Informational SCI with suppliers and the need to exchange relevant and accurate information in a timely manner. He explained that information accuracy was relevant because it supported both Operational and Relational SCI with suppliers:

> *We have to ensure our suppliers understand that we will need more and more supplies. They have to sometimes allocate between other suppliers in order to accommodate our needs. Most people are very understanding in a hopeless situation … they try and help you as much as possible. We have very good suppliers and they try and help us as much as possible.*

The interviewee simply mentioned the *Mitigation* stage after describing communication as the key to supporting resilience building—*'The Mitigation programme is very important, subsequently'*.

TC Tasha 2—Dairy SC-T2

Dairy SC-T2 is reported from the perspective of a manufacturer located near Brisbane that supplies warehouses and supermarkets that operate in Brisbane. TC Tasha had an indirect effect on the firm as a manufacturer, and a direct effect on some wholesalers, retailers and customers. Therefore, the manufacturer was analysed as DAO's supplier. One section of the SC downstream from the manufacturer was flooded, and products shipped to these buyers had to be disposed of. The rest of the wholesalers and supermarkets located outside the affected area were indirectly affected, as some trucks carrying products were not able to reach them due to inundated roads (see Figure 4-11).

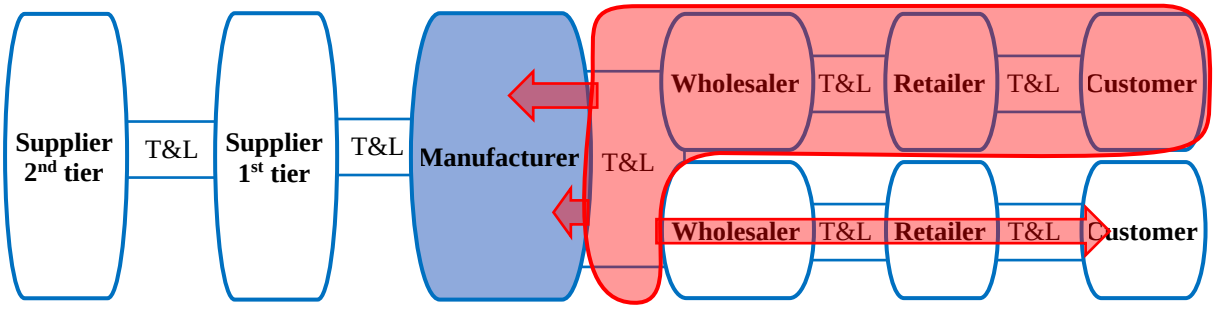


Figure 4-11: *Graphical representation SC-T2 and effect of natural disaster on it*

The firm did not stop operating as a manufacturer but needed one week to re-establish shipping via alternative routes, and one month to fully recover. The DAO, which was the wholesaler, needed one month to restart operations and up to one year to completely recover.

When describing the *Preparation* stage, the interviewee reported having established an emergency team and preparation plans that were communicated inside the organisation, indicating utilisation of Informational Internal SCI. The interviewee was able to describe safety measures that took place in the DAO during the *Initial Response* stage of resilience building—'*the importance where people are being moved into sheltered locations'*—and evaluation of damage and establishing controls that took place in his company:

> *So, I suppose from our perspective we had all of our stock, so the stock was fine. It was more about how do we get back to normality. You know, what's normal business. How quickly does that return to normal business as well.*

The interviewee did not have a chance to operate opportunistically due to late notice of the possible magnitude of the effect, but he recognised that Opportunistic Operations might be beneficial and should be considered in the future. This would include shipping in advance to avoid the effect of roads being severed by floodwater to place '*product in areas where people then can pick it up'.*

Informational Internal SCI during the *Initial Response* stage was described as communication downwards, upwards and between sectors in the company:

> *So, I would say cross-functionally we met monthly in normal circumstances but in crisis period you're talking daily to hourly.*

The interviewee reported Operational Internal SCI was supported by communication between sectors during the *Initial Response* and the *Recovery* stages in the DAO's supplier company and at the time the DAO was conducting the *Reconstruction* stage:

> *So, it's more just having that operational strategy so that the SC team knew what was happening but also sales, marketing and other teams need to be involved. You actually become more internally integrated in all terms during crisis than you do during normal business operations.*

The interviewee also discussed Relational Internal SCI:

> *It comes back to the values of an organisation, the values of the individuals. I think the human element of people during a crisis tends to shine through irrespective of where and who and how.*

He described exchanging information between DAO and DAO's supplier, from a supplier perspective:

> *So, we aimed to understand what is the long-term impact of this disaster together with our customers? What are their plans going forward?*

The *Recovery* stage focus for the interviewee's company was to rebalance to reach full SC recovery. As part of the discussion of this stage, the interviewee underscored the importance of Informational and Operational Internal SCI. It was stressed that communication between decision-makers, coordination of employees and increased effort on the part of employees were important to create alternative plans of operations towards full recovery:

> *So, taking an opportunistic approach to go now or not to go. Coordination of our operations, was very important, working together … Also, it was important that people were always wanting to try and support the organisation in some shape or form.*

Moreover, Relational Internal SCI was described as a foundation to develop good coordination and motivate employees to invest more effort:

> *I think because it's the right thing to do. When you look at it from a human front, human front supersedes the commercial front. Perhaps that just allows people to treat themselves as humans, as part of a big mission, not being just a number.*

The interviewee described Informational and Relational SCI between DAO and DAO's supplier as DAO being understanding but still demanding regular information and service:

> *Our customers were obviously understanding to an extent but still wanting results and solutions.*

He also described transparency as a main enhancer of trust and understanding during the *Recovery* stage:

> *It's more about being seen and having transparency and visibility as opposed to perhaps the results. So, if you were doing nothing, then obviously that wasn't good enough. But if you were seen to be doing all you could, then that also went a long way.*

In addition, Informational and Operational SCI with T&L service providers were utilised to support decisions in relation to operations:

> *Whether you knew you could get a vehicle tomorrow or not … a lot of it was about communication, getting up and saying: Yep, we've got ten vehicles stuck outside Brisbane that can't get in.*

However, the interviewee felt that a poor relationship with T&L providers was hindering recovery, since the latter did not observe SC recovery as a common goal:

> *We didn't have the ability to actually get products to customers, but also financially we had to pay a significant amount of dollars to get product moved into those regions. Our transport carriers obviously tried to make the most money they could … I would call it the scavenging nature of freight!*

A wider Informational SCI with stakeholders and shareholders was mentioned during the *Recovery* stage discussion. The interviewee showed concern for the community:

> *Because I was in the food business, we wanted to support individuals that lived in the community by providing food to people.*

The interviewee described the *Mitigation* stage as a revision of actions and consequences—'*You know, dealing with the situation at hand. Getting to the root cause, correcting it, moving forward'*—and Informational Internal SCI was utilised to support this stage—'*Communicate in the organisation, how to address it, how to improve it'*.

TC Tasha 3—T&L in white goods SC-T3

The white goods SC-T3 was discussed from the perspective of a T&L company that transports goods from wholesaler to retailers. TC Tasha had an indirect effect on the interviewee's company and a direct effect on some retailers and customers. In the analysis, the interviewee's company was placed in the position of T&L provider of DAO, and the retailer was DAO.

Some of retail shops were directly affected, with their interior inundated and a significant number of products destroyed. Further, the delivery route was not available even when shops were clean and able to receive goods; however, this had a lesser effect on retailers than inundation because customers were affected and few customers were looking to buy white goods before insurance claims were processed. The shops that were not inundated had affected customers, so delayed deliveries did not affect these shops as customers were not yet looking to buy white goods. The rest of the retail shops that were not affected and had regular demand suffered a downstream indirect effect, since some of the vehicles were trapped in the flood or roads reaching them were severed. The effect of TC Tasha did not go further upstream than the wholesaler (see Figure 4-12).

Figure 4-12

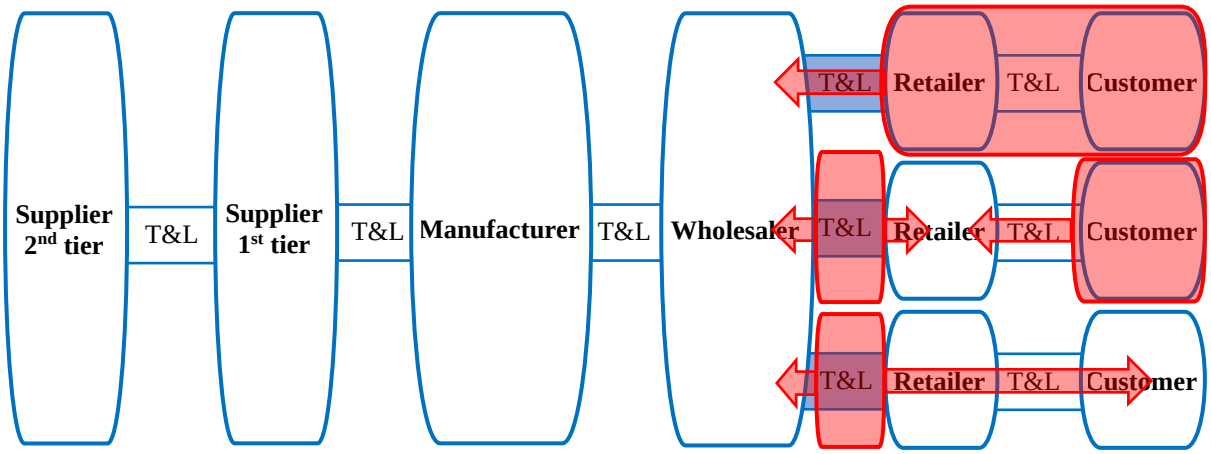


***Figure 4-12**: Graphical representation SC-T3 and effect of natural disaster on it*

Financial damage was inflicted on the interviewee's company because of delayed payments and the unavailability of isolated employees. However, these financial losses were deemed insignificant. SC-T3 was able to restart operations in six weeks and fully recover in two months.

When describing the *Preparation* stage, the interviewee confirmed that his company had provisions in place and an emergency team had been established.

The interviewee described the *Initial Response* stage as starting with a debate on whether to operate opportunistically, based on weather monitoring and previous experience. Opportunistic Operations to regions that were expected to be inundated were not advised by the T&L supplier but were advised in cases where roads could be breached, but the product destination would remain dry:

> *But for those organisations that are not in a directly affected zone we transport as much as we can, before the roads get closed.*

Subsequently, safety measures were described—'*They did all emergency evacuation, safety checks'*—and cleaning and reconstruction followed, together with damage evaluation:

> *They did renovations and stuff … and they'd cleaned their warehouse ... There were some substantial losses in that. We would have picked that up at a later time, a month or two later, by restocking the shop.*

Informational Internal SCI in T&L provider of DAO was described as communication upwards in the organisation, and communication between company sectors during the *Initial Response* and the *Recovery* stages:

> *We normally conduct the discussion with ourselves and our customers in, wherever they might be.*

The interviewee underscored the importance of Informational SCI between the T&L provider of DAO and DAO, and open communication and honesty:

> *We discuss our motives for either moving or not moving freight. For instance, we advise the customer and they could normally cancel the order and resubmit it later. The major thing is just being honest, being upfront, letting them know where we're at.*

The information exchange between the DAO and the T&L provider continued during the *Reconstruction* and *Recovery* stages. Describing the DOA's *Reconstruction* stage, the interviewee observed, '*They have to gut the building of all internals, make sure the wiring's good',* and added that Informational and Operational SCI inside DAO were utilised:

> *I know they had a lot of information coming back and forward between different teams, they coordinated those renovations and recovery among themselves quite effectively.*

During the *Recovery* stage, Informational SCI between T&L provider of DAO and DAO was utilised:

> *We normally advise the store, to hold deliveries. That way, when they're back on their feet they've got fresh stock.*

The interviewee also emphasised that Operational and Relational SCI between DAO and T&L provider was relevant:

> *We obviously supported our customers in any way we could, to ensure that their name, if you like, wasn't damaged in the marketplace.*

> The interviewee was unsure if the *Mitigation* stage has been conducted in his company.

TC Tasha 4—T&L courier SC-T4

SC-T4 is a T&L SC that transports mixed goods from retailers to customers in the Brisbane area. This small company uses vans to transport packets of chocolate and wines, hampers, calendars and other non-perishable items from one business to another. In this SC, the wholesaler, retailer and customers, as well as T&L company that links them, were directly affected. Additionally, the T&L company experienced an indirect upstream effect from directly impacted customers, and downstream effect from directly affected wholesalers and retailers (see Figure 4-13). Since customers were affected, they were unable to order goods in inundated locations. Some customers never recovered and were unable to pay delayed debts to the interviewee's company. The T&L company operated with about 65% capacity for the next four years, when the company was sold to a larger T&L firm.

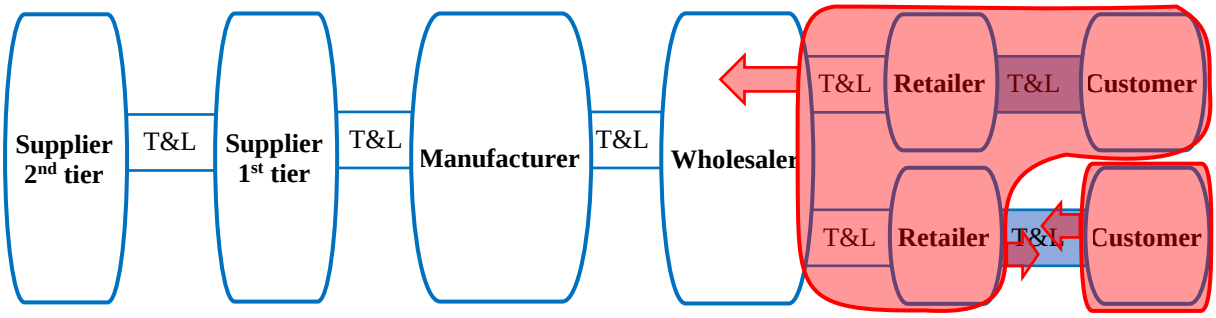


***Figure 4-13**: Graphical representation SC T4 and the effect of natural disaster on it*

The interviewee's firm did not have preparation plans or an emergency team, and he began the discussion by describing the *Initial Response* stage. He described Informational Internal SCI in terms of internal communication downstream in the organisation and Relational Internal SCI in terms of concern for employees:

> *One of the employees of the business lived down the bottom of the ranch and the road was cut off to get to her house and she spent the next three days living at our house.*

The interviewee did not dedicate specific attention to the *Reconstruction* stage since the location of his company was surrounded by floodwater but not internally flooded.

The *Recovery* stage was described in terms of restarting operations but also losing some of the largest clients that had not generated a lot of profit, but ensured operations were continued:

> *In the next six to 12 months we lost probably about two or three of our biggest clients.*

Informational Internal SCI was described as communication between employees, and between management and employees during the *Recovery* stage:

> *We had to speak about these events on a daily basis. We had to know where to go, who were our new clients if any and instruct drivers on changes.*

During the *Recovery* stage, the T&L company also relied on communication with buyers:

> *It was just that open communication, hey this is what's happening, this is what we're gonna do to deal with it and it was that proactive planning before ringing the customer telling them there was a problem that really created excellent communication going both ways.*

When discussing Operational and Relational SCI with buyers, the interviewee explained that relying on strong relationships and cooperation was possible when dealing with smaller disruptions, but of limited value during the disaster:

> *So, the only people we could ask were people who were already suffering, so there was no way that anyone could actually help us. It was just what they could do.*

The interviewee also addressed the lack of interaction and support from governmental agencies during the *Recovery* stage. This lack of communication and understanding between DAO and the government was described as hindering SCRES:

> *Where our business sat, it didn't qualify for any grants, any help from anyone. It's so easy for small businesses to fall in between the cracks and not be eligible for those grants that the government creates in order to ensure large businesses survive.*

The interviewee did not mention any operations in the *Mitigation* stage.

4.3.3 Hurricane Sandy (2012)

Hurricane Sandy affected the Caribbean Sea and six countries—including Jamaica, Cuba, Haiti, Puerto Rico, Dominican Republic and the Bahamas—before it made landfall near Atlantic City on 29 October 2012 as category 2 hurricane (Federal Emergency Management Agency [FEMA], 2018). Strong winds and rain demolished infrastructure and buildings in New Jersey, New York and the US more widely, causing disruption in 24 US states (Sales & Brissenden, 2012). Besides affecting thousands of kilometres of coastline, inland areas suffered disruptions due to heavy snow, which caused by the collision of Hurricane Sandy with two cold fronts (Sales & Brissenden, 2012).

Different sources disagree on damage estimates. Preliminary estimates by insurance companies sat around AUD20 billion (Muskal & Susman, 2012), but this was subsequently lifted to AUD52 billion (McCarthy, 2013; NOAA, 2012). However, more recent sources estimate the damage between AUD80 billion (NHC, 2018) and AUD98 billion (Milman, 2017; RBA, 2019 [exchange rate, date of source publication]).

Numerous ports were closed along the east coast, with over three weeks of delay in reopening and even longer needed to reach full operations (Leach, 2012; Vineyard, 2012). The initial damage occurred because containers were washed from the docks; trucks and other vehicles parked at the terminal and nearby were ruined; and electrical systems, equipment and cranes were severely damaged (Bonney, 2012). In addition to this initial effect, recovery was delayed because there was limited trucking capacity due to the power supply shortage (Bonney, 2012; Taylor, 2012), and because tankers carrying fuel were unable to distribute it due to the damaged terminals (Vineyard, 2012). The port authority reported that the most severe damage was experienced by the automotive industry. About 16,000 vehicles were stored in the US's

largest import port and thousands of new Toyota and FASP vehicles were damaged at the port and in transit (Bonney, 2012). Over 80 different calls were received from ships affected offshore between 24 and 30 October 2012 (Miami local time) (Blake, Kimberlain, Berg, Cangialosi, & Beven, 2013). For the purposes of the study, the types of ships making the calls were identified based on their call signs as two tankers, four bulk carriers, eight containers carriers, two vehicle transportation vessels and 24 passenger-carrying ships.

One of the SCs affected was automotive SC-HS1, which is examined in this study. To capture the effect Hurricane Sandy had on international shipping lines, which was the main effect that occurred in SC-HS1, the author developed a map (see Figure 4-14) based on Hurricane Sandy's track (NHC-NOAA, 2013) and global shipping lines (CIA, Esri, & Horner, 2013).

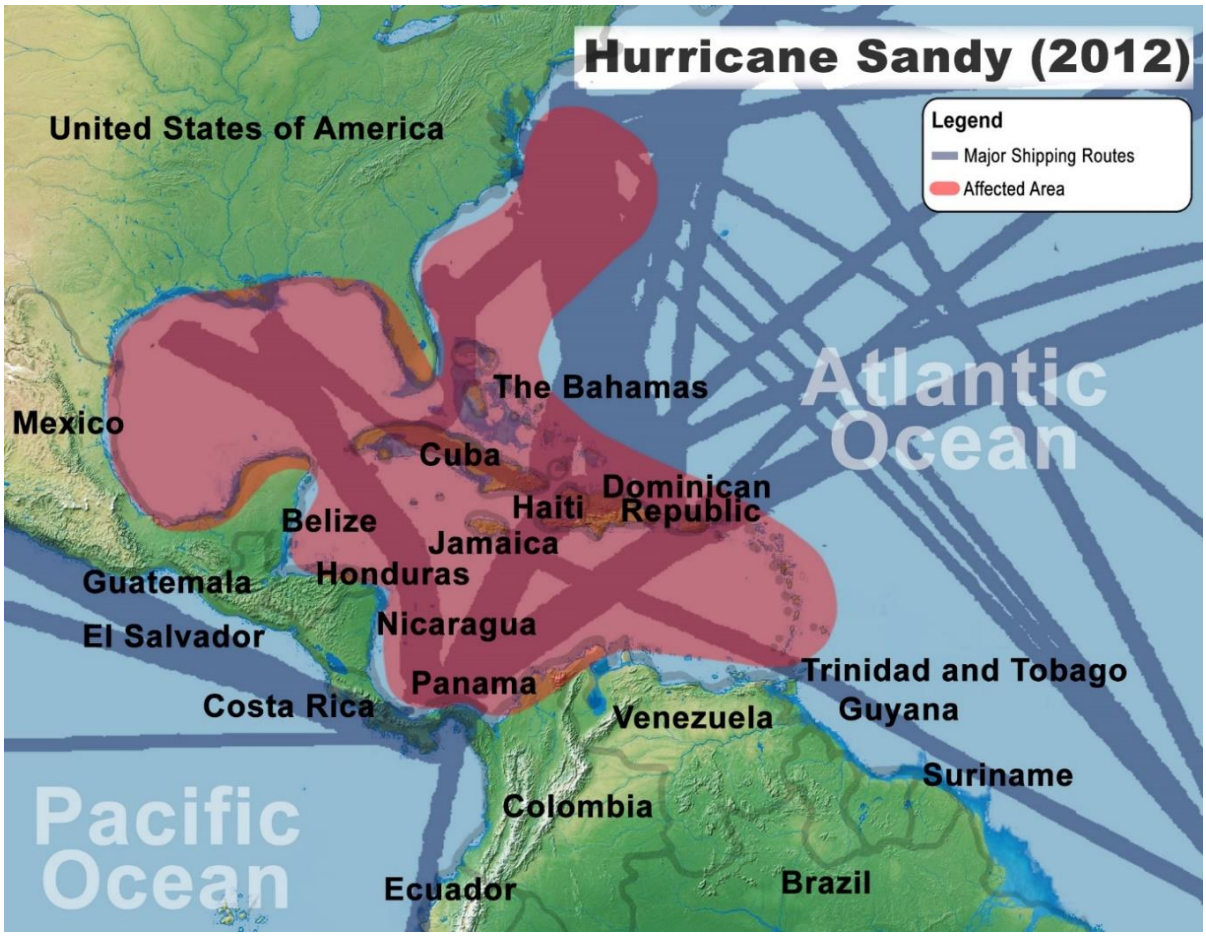


***Figure 4-14**: Influence of Hurricane Sandy on international shipping lines*

Hurricane Sandy—Automotive SC-HS1

The interviewee provided descriptions from the position of an automotive manufacturer whose firm was directly affected by the fact cargo was trapped and damaged in transit from

first-tier supplier in the US to his facilities in Australia. The relevant cargo was affected while being shipped through the Caribbean Sea.

The cargo trapped was damaged and some portion of it was lost. There was an upstream indirect influence on a supplier to increase production in order for DAO (i.e., manufacturer), to be able to make up for lost cargo. A downstream effect was induced by delayed delivery to buyers, but no effect further than wholesalers was detected, as presented in Figure 4-15.

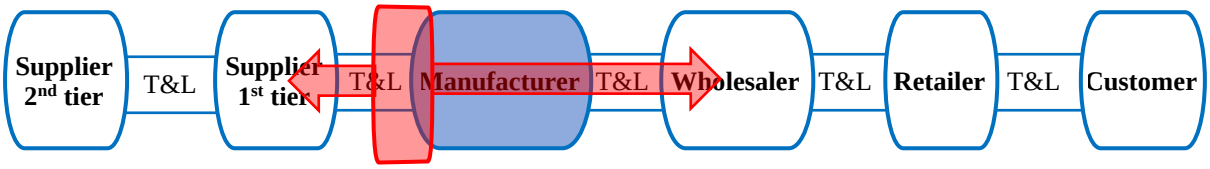


***Figure 4-15**: Graphical representation SC HS1 and the effect of natural disaster on it*

The interviewee described the damage as minimal, but he also mentioned production was reduced for three of four weeks, and that despatched shipping containers were late. In addition, costs were generated because alternative shipping lanes had to be utilised that were more expensive but faster. This meant that some costs did appear, but due to the scale of the natural disaster they could potentially have been much higher, so interviewee described them as minimal.

The interviewee described the *Preparation* stage in terms of the existing plans for the specific region:

> *The southeast area is prone to ... tornadoes and winds. And ... you always need some sort of contingency... to ensure that your SCs continue to work and product moves through the SC.*

He added that the T&L provider was included in early negotiations and their role was embedded in precautionary plans. He described Informational SCI with T&L provider:

> *When you negotiate your sea freight rates, okay, you have to have a backup lane. So, you have a lane that is instead of moving through the east coast of America you move product through the west coast of America.*

These negotiations of the alternative transport modes and routes, especially in anticipation of the hurricane season in the specific area, indicates Early Anticipation during the *Preparation* stage. The interviewee also confirmed that the company has an emergency team established. Informational and Operational Internal SCI were utilised to rehearse the existing preparations plans and ensure they were likely to work—'*they are utilised, tested and in practice they work'*.

In the discussion of the *Initial Response* stage, the interviewee described being warned that a natural disaster might affect his freight about one week in advance. He explained the supplier was not directly affected, but cargo in transit that was already sent to DAO was affected. However, other than assuring alternative ways for shipping, which was done in the *Preparation* stage, nothing further could be done at that point in time. He called his emergency team meetings the *'war room'*. Meetings held during this SCRES stage were supported by Informational and Operational SCI with T&L suppliers and goods suppliers:

> *You use the team that you have. You use your freight porter and you use your supplier. So, you look at contingencies and what contingency SCs you have.*

Informational SCI with suppliers, buyers and T&L providers was additionally emphasised as important—'*You need to have a very good communication lead between everybody. Buyers need to be informed'*. Relational SCI with T&L provider was described as necessary for the *Initial Response* and the *Recovery* stages—'*Obviously you need to have very good relationships with your [T&L] suppliers'*.

Informational Internal SCI involved an increased frequency of meetings during the *Initial Response* and *Recovery* stages:

> *So, you normally have a ... conference call on a daily basis and then you would have daily meetings amongst your own internal people.*

Discussion on Operational and Relational SCI internally was joined for *Initial Response* and the *Recovery* stages. The *Reconstruction* stage was not conducted as there was no direct effect on the location of the interviewee; therefore, the *Recovery* stage included:

> *The next step is to continue to monitor the situation until your SC or your transportation route is returned back to normal. Once you return back to normal then you go back to your original contracted route.*

In this stage, the interviewee described multiple internal and external teams working together, while referring to Operational SCI internally, with T&L provider, and with supplier:

> *So, you've got to work with your production team, you've got work with your materials management team, the logistics team. And your freight forwarder and your supplier and your shipping line. It all has to work together. Otherwise, one person does the wrong thing and brings the whole SC down.*

The interviewee stressed the importance of Relational Internal SCI in terms of the need for a close relationship between employees—'*Times of crisis bring people together. It was very good'*. He reported the close relationship was supportive of Operational Internal SCI in terms

of employees working longer and putting in more effort to further a common goal—'*People put many hours in and were always willing to stay back and work long hours'*. Relational Internal SCI was also described in terms of trust, as the interviewee believed employees trusted him as both a leader and manager:

> *Leading by example is what motivates and brings out the best in people. So that's my style. I don't ask people to do anything I wouldn't do myself. Moreover, the calibre of people that we hired were professional and had pride. And took ownership of the work that they performed.*

The *Recovery* stage discussion also included a description of Informational and Operational SCI with suppliers, wherein regular information exchange was emphasised and coordination of operations was deemed crucial:

> *We would send in daily production schedules or demand schedules on a weekly basis and negotiated a plan on how much production they need to bring forward. Or increase.*

The interviewee argued that strong relationships served Operational SCI with suppliers:

> *The idea is to build a relationship and a collaborative working relation with suppliers and that's where that works. A strong relationship is crucial.*

In addition, Relational SCI with buyers was described as mutual understanding based on good communication—'*The relationship had been built and they understood our business and our priorities'*.

During the *Initial Response* and *Recovery* stages, the interviewee described communication and coordination with ports and other authorities that supported SCRES building, while the *Mitigation* stage centred analysis on refining plans in the light of the disruption experienced.

4.3.4 Tropical Cyclone Lua (2012)

TC Lua affected the west coast, northwest and central parts of WA in March 2012. This area is remotely inhabited but hosts multiple large mining companies, including BHP Billiton, Atlas Iron, Rio Tinto, CITIC and Fortescue Metals Group (FMG), accounting for about 40% of the global seaborne iron ore trade (Chin & Rudan, 2012; Stewart, 2012). In addition to mining and energy companies, there are two major ports importing and exporting iron ore and other minerals in the area: Port of Dampier and Port of Port Hedland.

On 13 March 2012, BOM warned that TC Lua might affect the Pilbara. In response to this, Apache Corp stopped production at the Stag oil field (Brindal, 2012) and Woodside

petroleum closed operations at six oil fields (Australian Associated Press [AAP], 2012a). In the following days, TC Lua intensified and safety procedures in Port Hedland and Port Dampier were initiated. CITIC Pacific Mining and Chevron Australia began evacuating staff; Santos disconnected floating storage facilities and stopped production at the Mutineer-Exeter oil field (Bell, 2012b; K. Robertson, 2012); and Rio Tinto suspended operations in three ports (Stewart, 2012). In addition, some miners, such as FMG, started opportunistic production to produce as much product as possible before the direct impact (Spooner, 2012; Stewart, 2012).

On 17 March 2012, TC Lua made landfall on the coast of the Pilbara. It was the strongest TC besetting the WA coast since 2009. The affected region received heavy rainfall (BOM, 2012b) and the category 4 cyclone hit Port Hedland at 3 pm. TC Lua reached the northwest coast with winds of 220 km/h (AAP, 2012b) and a red alert was issued to mining areas and coastal communities (Radio New Zealand, 2012). Major Woodside oil fields and Atlas Iron mines ceased operating for an extended period (AAP, 2012c).

Although TC Lua did not significantly damage buildings and infrastructure, it caused severe disruption to mining, oil and gas production (van Vonderen, Norman, & Reader, 2012) and severely disrupted the operations of the ports. Port Hedland, which usually ships about 700,000MT of ore daily, was closed for several days (Spooner & AAP, 2012), and in March 2012, shipping fell 5% (Bell, 2012). Port Dampier shipped 11% less iron ore than its annual average, and 7% less than the average for the month of March (PPA, 2019).

To capture the effect of TC Lua on mining SCs in the area, the author developed the map presented in **Figure 4-16** (adapted from BOM, 2012; DIRDC, 2015; Geoscience-Australia, 2015). The SC-L1 examined in the context of this disaster is a mining SC.

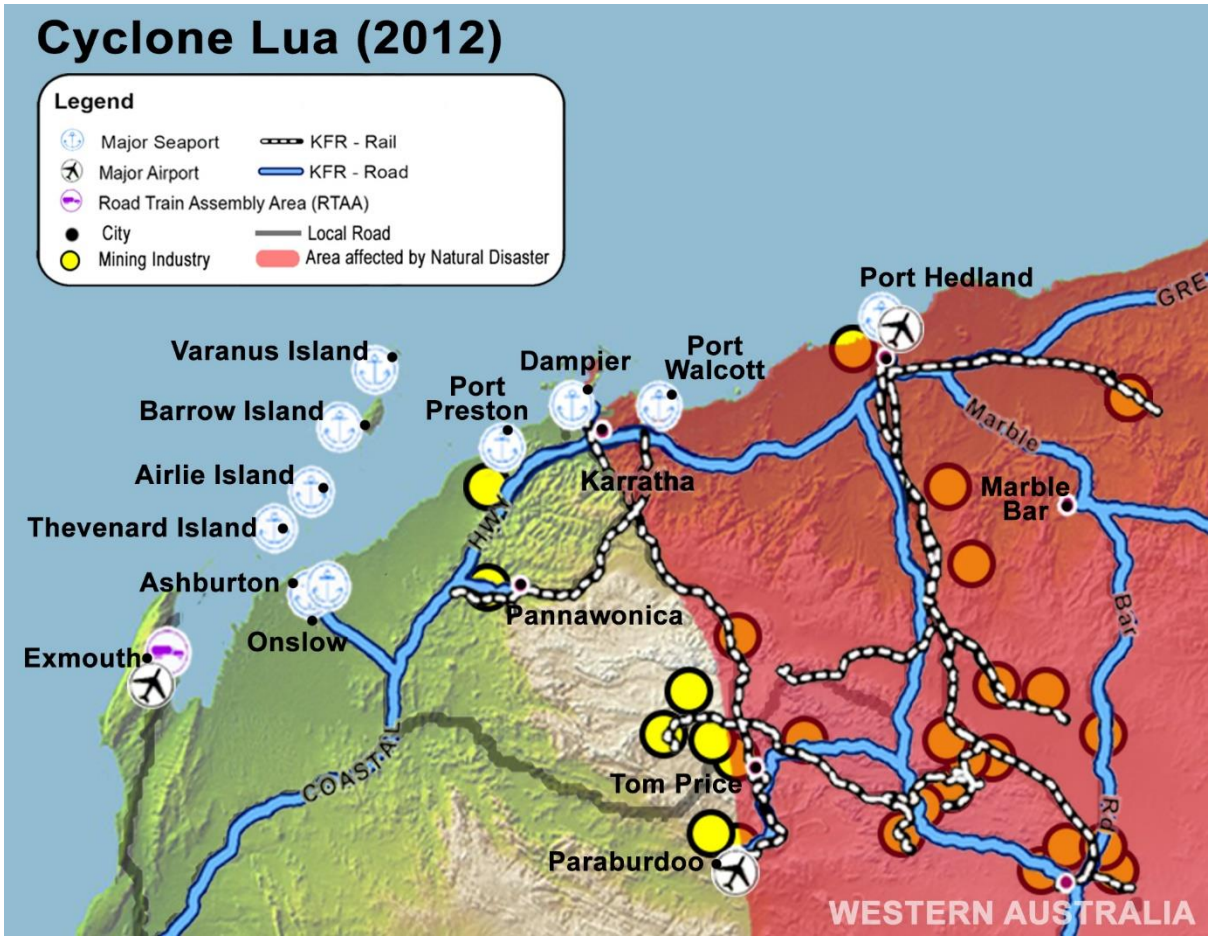


***Figure 4-16**: Influence of TC Lua on mining SCs*

TC Lua—Mining SC-L1

The interviewee described the effect of TC Lua from the position of a second-tier supplier that was directly affected by flooding in the examined mining SC-L1. The DAO's location was not affected by strong winds, although infrastructure and T&L suppliers were and some structural damage occurred.

The effect of TC Lua was transferred downstream in the SC, although the interviewee was unable to witness the effects beyond his buyer. In the discussion, the DAO also reported that his suppliers (smaller mine operators) were directly affected, as presented in Figure 4-17.

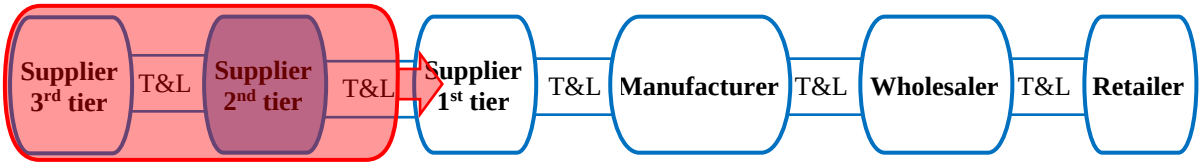


***Figure 4-17**: Graphical representation SC-L1 and the effect of natural disaster on it*

In the discussion of the *Preparation* stage, the interviewee described the character of the emergency team:

> *There's a group of people who are based in Perth who have specific roles. So there is someone in charge of external communication, someone with responsibility for communications with the mine site, somebody charged with internal communication, and those people will be basically available 24 hours.*

He also described plans that exist in the DAO as a result of prior risk assessment, and financial plans embedded in the resilience building:

> *It's important that you plan upfront, and that part of that planning is some level of risk assessment. In terms of a financial planning and operational planning model, you're assuming lost.*

The interviewee additionally reported that Early Anticipation existed in the form of the plans and budget being adjusted specifically for natural disaster that is seasonal, planning for reduced operations and a decrease in profit:

> *You're actually reducing the number of assumed shipments in those months … you're assuming that you're going to lose days, you're going to lose some over that period of time.*

The interviewee held that relationships with government organisations in the *Preparation* stage were important and stressed the need for business firms to let government agencies know they need to receive detailed notifications when a natural disaster is approaching:

> *So, if you have a business or an interest in a business, you want to get on board with the BOM and DFES, register on the BOM website for alerts, and then every day through the season you will receive an email alert with basically an outlook.*

The *Initial Response* stage is described in terms of transport activity reduction and operations reduction on the site and, finally, the application of safety measures:

> *When a cyclone happens, everything stops, and typically the infrastructure that will stop first is the ports. You make sure that you've got sufficient bookings in cyclone-resistant shelters for the staff that you're going to keep. So four days before, you start to reduce your manpower. Three days before, you start to reduce physical movements. Two days before, you basically start to lock down mine sites, lock down assets. Then one day before, you don't want to be doing anything, because these things can slow down or speed up.*

This also indicates Opportunistic Operations, since the interviewee's company continued operating as long as possible and reduced manpower just a few days before the direct impact.

When discussing the emergency team, the interviewee indicated that Informational SCI between DAO and buyers and suppliers was employed. In addition, Informational Internal SCI

was reported as being important in terms of communication between different sectors in the company and downwards, from central management to mine site. Further, he stressed that frequency and continuity of communication was important for SCRES building.

The interviewee described Informational Internal SCI in terms of consistent and clear communication downwards from decision-makers to managers charged with supporting Operational Internal SCI through coordination of safety-related activities—'*So that you get that consistency of coordination, and decision-making at the appropriate levels'.*

The interviewee described Relational Internal SCI as care for employees, their safety and reducing stress on them and their families. He repeatedly said '*we'* and '*our employees'* when discussing the *Initial Response* and safe accommodation:

> *We want to keep our people safe, fed, and watered. So, we're trying to get our people safe, they need to be alright.*

The interviewee also stressed the management's appreciation of employees' efforts and insisted concern for employees' families was paramount:

> *You're able then to give that information to their families and loved ones, when they say, 'I'm trying to phone the mine site, and all the phones are down'. We can say, 'Well, we're getting these satellite communications, the last one we got, it was a green light so all's well'.*

The interviewee continued explaining the importance of Relational Internal SCI for the *Reconstruction* and the *Recovery* stages, indicating that results in increased Operational Internal SCI:

> *So, it's just, I guess, number one it's doing the right thing, which is really important, and number two because you're doing the right thing, hopefully people perceive and understand that. If you're doing that in a visible sense, and I guess in a humble or transparent sense, then people can see that and hopefully they feel good about the organisation that they work for as well.*

The *Initial Response* stage also included a description of Informational and Operational SCI with T&L provider in terms of coordination of flights for transporting employees outside of the mine site when manpower was reduced to further the need for safety.

Informational SCI with smaller mine operators in the area was described as insufficient to support this stage, since the interviewee described this as '*one-way communication'.*

The interviewee described communication with governmental organisations in terms of regular updates from BOM. It was also important to communicate with the publicly owned port

to coordinate a reduction in the number of vessels held and communicate with road authorities about road closures. The interviewee additionally described sharing responsibility for the road infrastructure repair with Main Roads WA during the *Initial Response* and *Reconstruction* stages, to help reconstruct infrastructure.

The interviewee also expressed some disappointment regarding cooperation with public organisations such as ports and road operators, observing that it was one-way communication and entailed a '*conservative*' provision of notification.

Evaluation of damage and reconstruction took 12 days. It was supported by Informational and Operational Internal SCI through constant communication between sectors and downwards in the organisation, and coordination between actions undertaken.

The *Recovery* stage was described as involving a slow restoration of operations and reaching full operations with minimised financial cost. Informational and Operational Internal SCI was utilised in this stage to further communicate with and coordinate employees. Relational Internal SCI proved important in attaining this goal. All three of these of SCI are reflected in the following:

> *Because they are a fly-in fly-out workforce, the majority of workers don't all appear on day one. So, you've actually got to schedule relationships to prevent this from happening*

When discussing the *Reconstruction* stage, the interviewee described communication with T&L providers as particularly important and stressed that this was made easier if these firms believe your enterprise has a robust Operational agenda:

> *You've got the recovery plans in relation to getting people back into the area, so that's about booking out space with airlines. The airline is more likely to want to play ball, in terms of freeing up seats for you if you had a transparent plan.*

The interviewee also added that Relational SCI with this T&L provider was central to gaining their support:

> *Manage relationships with the airlines, so you're getting capacity on the flights into Port Hedland when they reconnect … It was our joint plan for that transport piece, not their plan or my plan, it was one plan.*

The interviewee described Informational SCI with buyers during the *Reconstruction* stage—'*We actually gave them visibility of when we were going to have product at the port, ready to go'*—and the lack of Relational SCI with buyers—'*They had very little, very little understanding',* which hindered the recovery effort.

The interviewee emphasised the need to establish and sustain a close relationship with the managers of public organisations, such as port authorities and Main Roads WA. He explained the importance of building relationships beforehand, as a part of the planning cycle, to enhance the likelihood of these public organisations understanding the needs of a DAO, which helps accelerate the recovery process:

> *You've got a relationship with two key stakeholders, being Main Roads WA and the port authority, such that you can coordinate what you're trying to achieve, such that you get an outcome more quickly … It's the relationship beforehand. It's a waste of time trying to build a relationship when it's thunder and lightning, you've got to spend the time building a relationship when times are good.*

The interviewee also advised that while state assistance is valuable, governmental organisations are not always adequately accountable for their actions and communication should not be one-way, as this was unfair to his firm.

The *Mitigation* stage was described as a review process that evaluated the *Initial Response*, *Reconstruction* and *Recovery* stages with the aim of improving resilience in terms of reducing time to full recovery and minimising the financial impact of the disaster:

> *Yeah. it's basically going over what worked and what didn't work … you need to reflect on what you did, what you didn't do, what you would do differently next time. So, it's basically that review with the appropriate people, with the experience in the room, to actually learn from those actively involved in addressing the crisis, almost like an incident investigation. Just what did and what didn't work. As I said, it's absolutely critical to reduce periods of decline and periods of recovery, as best you can.*

In the foregoing observation, the interviewee underscored the importance of Informational Internal SCI. Expanding on this issue, he emphasised the significance of Informational SCI with different T&L providers and public organisations during the *Mitigation* stage. Specifically, he noted that it was important to notify these latter agents about how your plans have improved to be even better in the face of a future disaster, as this process is likely to assist them to aid the *Recovery* stage:

> *Those public suppliers are much more willing to sit around the table when you're doing a desktop risk assessment, when they know that I've just gotten through that, and when you make sure they know you have considered your experience and determined that you could have actually done some things differently and will do so in the future.*

4.3.5 Tropical Cyclone Marcia (2015)

TC Marcia lasted from 19 to 22 February 2015, bringing strong winds, heavy rains and flooding to Central and Southeast Queensland (Caroll, 2015). Although the flooding was short-

lived, it was extensive, with three large river basins flooded: the Fitzroy River, Burnett River and Mary River catchment (BOM, 2015). In total, 14 out of 77 regions in Queensland were proclaimed disaster zones (ICA, 2015a).

In the early morning of 20 February, category 5 superstorm Marcia made landfall in Yeppoon (BOM, 2016), about 540 km north of Brisbane, with winds reaching 285 km/h (Ahmat, 2015). Soon, TC Marcia weakened and headed towards Rockhampton, bringing high tides, heavy rain and destructive winds as a category 4 cyclone (AIDR, 2015). Significant structural damage was recorded in both regions (Koubaridis & AAP, 2015). The most extensive rain was recorded on the Sunshine Coast and in the Mary River catchment area (BOM, 2015). In addition, monsoonal clouds were attracted to the area from the southeast by the cyclone, contributing even more rainfall (Pierce & Gutro, 2015).

The next day, on 21 February, TC Marcia reached Brisbane with reduced windspeed but severe rainfall that affected the city (Pierce & Gutro, 2015), inducing severe flooding (Van Vonderen & Woodward, 2015). Overnight more than 100,000 properties lost electricity (AAP, 2015a) and hundreds of thousands of properties remained without power in the following days (Ahmat & Grant, 2015; Enus, Petersen, et al., 2015).

More than 80% of businesses operating in the affected area were disrupted (DILGP, 2015). There was extensive road closures (almost 1,000 km closed) and telecommunications infrastructure was damaged (DILGP, 2015). Six ports and eight airports were closed, as were passenger rail lines (DILGP, 2015).

Rail operator Aurizon calculated the impact on the firm's Earnings Before Tax and Interest (EBIT) at between AUD24 and 28 million (AURIZON, 2015). The estimated financial impact on the SCs that relied on rail services, including coal and intermodal services, was AUD10 to 12 million, and estimated damage to the agriculture industry was AUD200 million in infrastructure and production loss (DILGP, 2015). By May 2015, the ICA had received over 35,000 claims, with losses estimated to reach AUD446 million: AUD307 in domestic claims and AUD139 million in commercial claims (ICA, 2015b).

Some of the SCs affected in the 2015 disaster were SCs M1, M2, M3 and M4, examined in this study. To visually represent the effect TC Marcia had on the same industry as examined in the case SCs, the author developed a map (see Figure 4-18), which includes main population centres and infrastructure (adapted from BOM 2015, 2016; DIRDC, 2015).

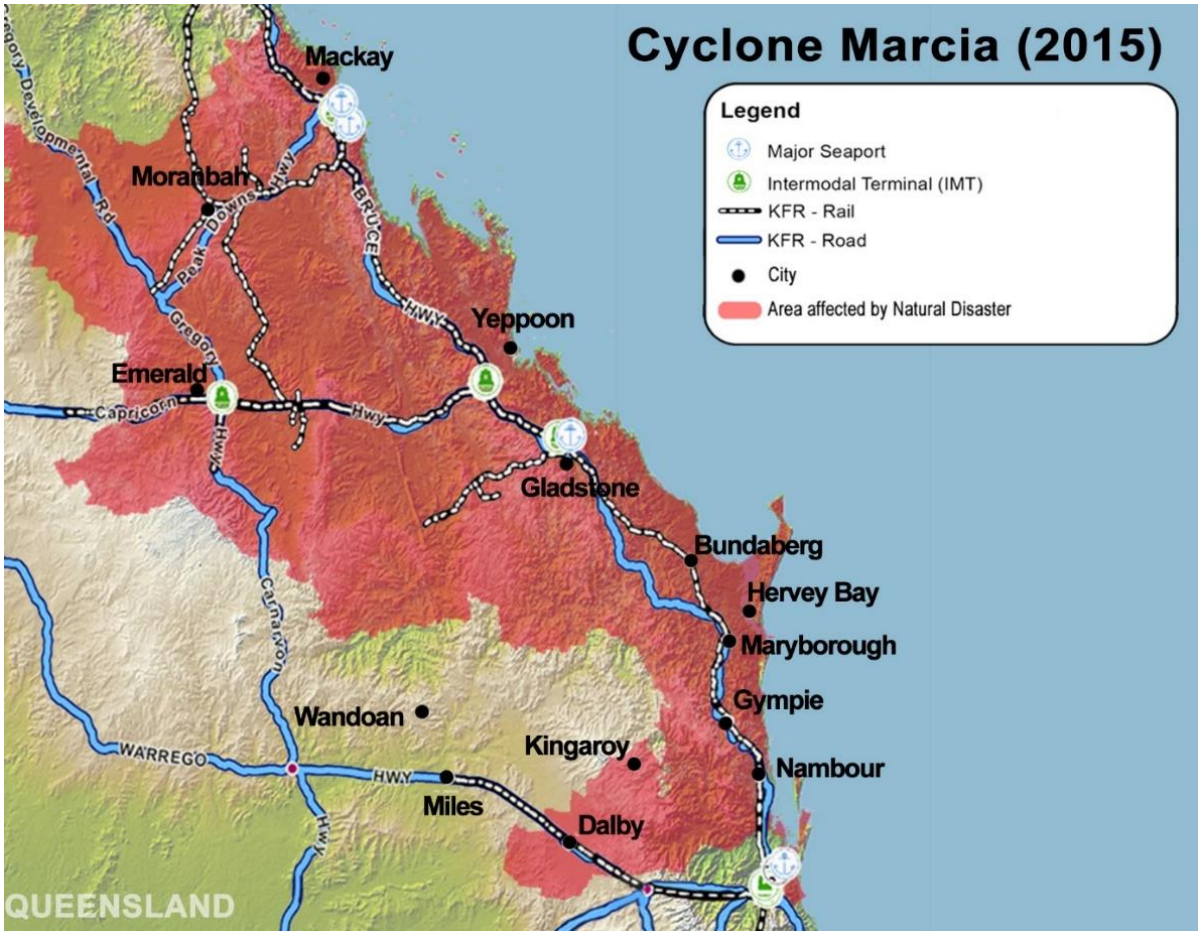


***Figure 4-18**: Influence of TC Marcia on SCs*

TC Marcia 1—Food SC-M1

The SC-M1 is a food SC. In this study, attention is centred on a manufacturer in the northwest area of Brisbane. The interviewed SC manager comes from a company that distributes products all over Queensland. Manufacturing and warehouse facilities were not destroyed by winds or inundated; however, the site was surrounded by floodwaters that submerged much of the area utilised to indirectly support operations. This hindered the movement of products and employees and required substantial cleaning afterwards; therefore, the manufacturer is analysed as a DAO.

The manufacturer lost AUD500,000 in lost production and wages paid to a workforce that was unable to work; however, planned sales were recouped afterwards. In an operational sense, the DAO was affected through interrupted operations for two days. However, additional indirect effects on the DAO occurred in terms of inability to transport product even after two days, and the longer recovery times of wholesalers who were not able to receive products when the DAO was ready to produce and deliver.

Before the water withdrew from the manufacturer's location, the direct effect of TC Marcia was felt along the entire SC, even reaching customers, since the entire area was flooded. This effect was transferred to the transport provider and first-tier supplier, who were indirectly affected. There was no indication of an indirect effect reaching further up SC (see Figure 4-19).

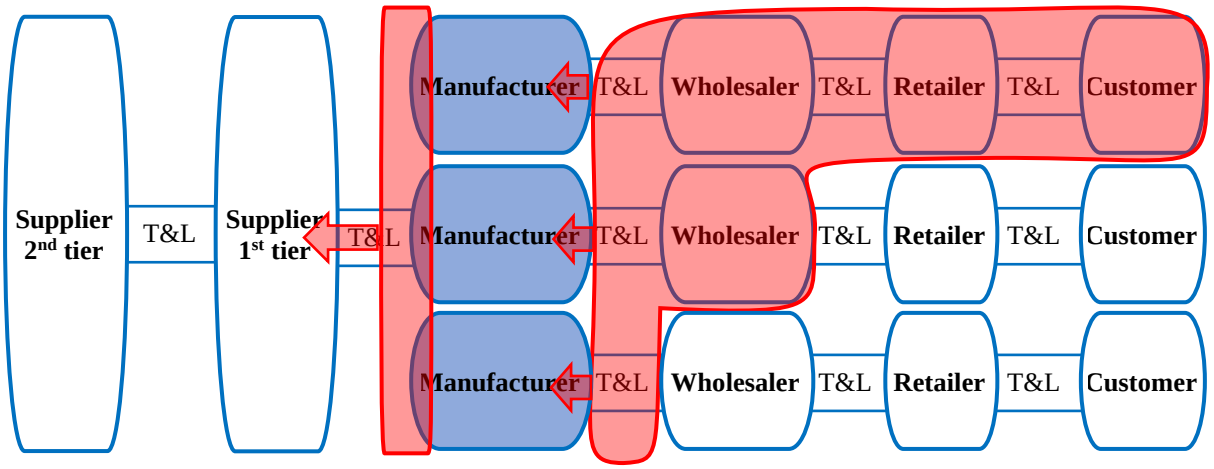


***Figure 4-19**: Graphical representation SC-M1 and effect of natural disaster on it*

The interviewee described the *Preparation* stage of SCRES while discussing the emergency team and preparation plans in place, thereby emphasising the importance of Informational Internal SCI during plan development.

The interviewee started the discussion on the *Initial Response* stage by explaining that the event was not predicted. Less than two days before the disaster directly beset their location, there was some ambiguity about the potential effect and in the following days an emergency team was mobilised. Safety concerns had risen, so safety plans were put into practice:

> *Some people were unable to return home and were trapped on the company premises, so we had beds assembled in the factory. That is standard procedure. We had a small evacuation centre here, to accommodate people who could not leave because the flood surrounded us.*

After the safety measures were put in place, the emergency team met every day and sustained an ongoing process of evaluation regarding damage on the business and what needed to be done to re-establish control.

Informational Internal SCI utilised to support these operations engaged communication downwards, from emergency team members to employees—'*Each manager, representative of*

one sector in the Emergency team communicated downwards in the organisation'—and this communication supported Relational Internal SCI:

> *Transparency and communication inside the company brings internal trust. Tell your employees what is planned, identify goals, share why things are being done.*

The interviewee described Operational Internal SCI as coordination that supports quick reactions:

> *Coordination between business units needs to be better during a crisis and that is crucial! Fast and rehearsed reaction!*

He also reported on Informational SCI with buyers and suppliers, and stressed that this is important during this SCRES building stage—'*Update your buyers immediately and update your suppliers. Tell them what is happening'*.

Communication with authorities and governmental organisations initiated during the *Initial Response* and *Recovery* stage was maintained until the SC reached full recovery:

> *We were in constant communication with the authorities, because we needed to know when the flood was going to withdraw from the town our employees live in … when are roads going to reopen, when will we be able to re-establish lines of transport with supplier and with buyers.*

While trying to re-establish operations, the firm had to perform cleaning activities, which extended the *Reconstruction* stage and halted production for three days. When the water withdrew and all facilities were reachable, they needed another three weeks to reach full capacity of operations. The interviewee reported that Informational, Operational and Relational Internal SCI all proved important at this time. He held that Informational SCI supported Relational SCI, and Relational SCI supported teams to work together, which resulted in faster recovery of the entire SC:

> *Internal communication, constant visibility and understanding were very important in handling the cleaning and recovering from the event. Teams needed to trust each other and the organisation. We had that internal understanding. Each team had to trust another team. That is how we work well together.*

During the *Reconstruction* stage, the interviewee emphasised the importance of communication with buyers—'*Communicate. Update your buyers regularly and accurately. That is crucial*.' Informational SCI with buyers and suppliers was described as supportive to Operational SCI with suppliers, and supportive to Relational SCI with buyers, with transparency central to buyers' understanding.

The interviewee described the *Mitigation* stage as involving the gathering of teams to share knowledge and learnings and to update existing plans—'*We gathered to join knowledge and share experience and come up with the contingency plan!'.* The DAO also used good communication and coordination to support conducting the *Mitigation* stage:

> *We have teams gathering, such as a crisis team gathering, every month. We practice and watch what would we do in an emergency situation like this.*

Good communication and coordination during the *Mitigation* stage were described as supportive to conducting the *Initial Response* and the *Recovery* stages in future disasters. This practice brings employees together and increases their trust that the organisation's managers know what they are doing. Building these relationships outside an emergency situation supports SCRES building during the *Initial Response*, *Reconstruction* and *Recovery* stages:

> *You need to build trust outside of a crisis, outside of a natural disaster. Then, in natural disasters, teams will cooperate well and know what to do, they know you know what you are doing.*

TC Marcia 2 – Non-perishable Retail SC-M2

The SC M2 is a retail chain and the SC manager interviewed comes from a wholesaler company. They buy from multiple manufacturers overseas and in Australia, and sell mostly non-perishable but also some perishable products. The wholesaler's hub is located in Brisbane and the retail stores it supplies are all over Queensland. While the wholesaler's location was not directly affected, two retail stores were directly impacted by being inundated and surrounded by floodwater. These stores reopened five days after initial impact. In the meantime, customers were redirected to nearby stores, which had above-normal sales. The wholesale and retail company are under the same ownership, and the wholesaler has been analysed as a DAO.

The T&L company operating between wholesaler and retailer was directly affected due to severed rail lines and roads, and the majority of the outlets' local customers were directly affected by floodwater. However, in this case, the direct effect on customers was two-fold: first, through reduced purchasing of regular products; and second, through increased demand for specific products related to the flood. The wholesaler utilised significantly more expensive transport for delivery of the latter. The indirect effect of flooded infrastructure and directly affected T&L company on the wholesaler, was only visible in terms of a small body of goods being damaged and financial losses did not exceed AUD1,000.

The indirect effect on the transport company and retailer was transferred upstream to the wholesaler, who had to reduce despatches and use alternative routes. In addition, the wholesaler reported that the impact of the natural disaster did not reach further up the SC. Manufacturers were not affected because the wholesaler pre-ordered all stock that normally peaks during natural disasters (see Figure 4-20).

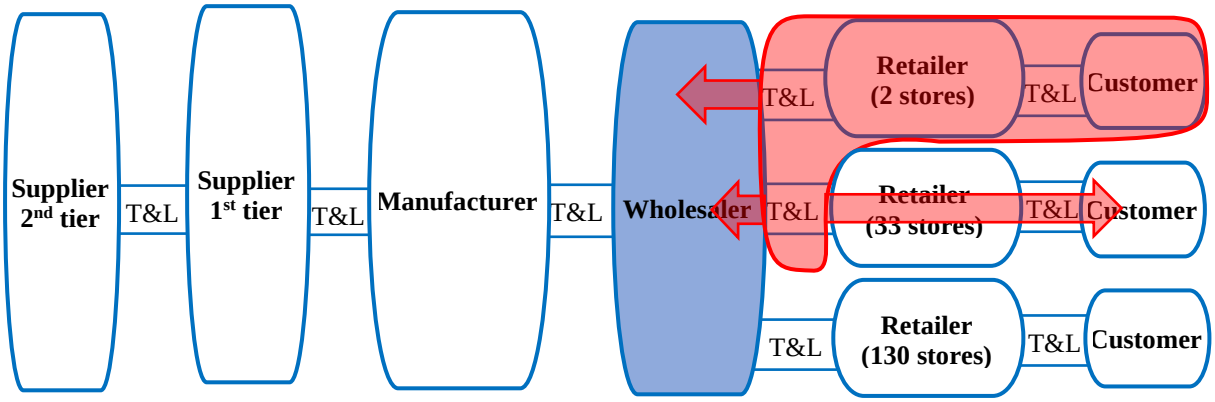


***Figure 4-20**: Graphical representation SC-M2 and effect of natural disaster on it*

When describing the *Preparation* stage, the interviewee observed that in Early Anticipation of the cyclone season, they began amassing stock months before TC Marcia—'*We tend to pre-plan to mitigate the event, buffer stocks are collected well ahead of the event.'* However, the amassed stock only included goods expected to be in high demand during a natural disaster, such as plastic tubes, mops and similar. The interviewee mentioned that multiple teams were involved in this process and indicated Informational and Operational Internal SCI was used to support the *Preparation* stage.

When the danger of the natural disaster was forecast, the interviewee described the first step in the *Initial Response* stage as opportunistic shipping from the wholesaler's location to the retail stores—'*We send all our stuff on rail to our retail stores'*. These operations were supported by Informational and Operational Internal SCI. The interviewee added they were aware of the potential impact six days in advance. After this, safety procedures were operationalised in stores in the areas that were expected to flood—'*Once it was known which stores would be inundated further safety measures were enacted including evacuation of staff*.' As soon as water began to ebb, the stores were cleaned and preparations to restart operations were begun.

The unaffected stores continued selling and entered the *Recovery* stage earlier than the inundated stores, which stopped operating for five days. The unaffected stores sold products

and tried to generate profits for faster recovery of the stores that were still in the *Initial Response* and *Reconstruction* stages. Inundated outlets awaited safety warnings and when these were received, entered the *Reconstruction* stage. This involved repairing, cleaning and preparing to reopen:

> *They gave it a cleanout. Obviously, we had some impact to stock and equipment, so there was a write-off there.*

The SC manager explained that stock levels in stores that continued trading but were unreachable from outside the district were tracked to identify what was being depleted so they could prepare to ship these goods once the stores could be reached.

Informational and Operational Internal SCI was described as information exchange and coordination between different teams in the company during the *Initial Response* stage—*Obviously, having central command and control systems as well, so one team orchestrates it*—as well as sending additional teams of employees to directly affected areas to support the *Reconstruction* stage—*In brief, you basically fly in a property team.*

Communication with buyers during the *Reconstruction* stage was discussed when describing Informational SCI with customers, which primarily entailed redirecting them to other stores until the inundated stores reopened. When discussing both the *Reconstruction* and *Recovery* stages, the interviewee underscored the importance of information exchange with government-owned organisations that provided information of alternative routes to support inundated stores and stores with depleted stocks:

> *We would get guidance from the rail providers, which let us know when the storm had passed and this guidance was utilised to make critical decisions that would facilitate the complete reconstitution of the SC.*

He added that this communication continued, and coordination of their activities for mutual benefit was crucial during the *Reconstruction* stage of inundated stores—*'So we would wait and communicate with public organisations and coordinate our transportation with them'.* The interviewee also explained that in some cases, they worked with government officials to provide people with water bottles, plastic tubes to elevate furniture, and similar items that became vital during the *Reconstruction* stage.

Once all stores could be reached by transport, the SC manager observed that the *Recovery* stage began. This entailed discussing which shipping methods would most effectively restock the shelves in the stores. This process was supported by Informational Internal SCI in terms of communication upwards:

> *We basically submit what we decide to the GM, general manager and we get them to sign off once they have considered input from the general manager of merchandise, and the general manager of stores.*

The SC manager held that Informational and Operational Internal SCI was important and made coordinated decision-making between sectors possible—'*All teams work very well together. Very coordinated, all knowledge and experience-based*.'

Employee turnover was deemed an important factor for knowledge-based creation and utilisation of Informational Internal SCI during recovery:

> *If you have a very transient SC team, they're in one year, out the next, you lose that intellectual property along the way and this is particularly important given flooding is a regular occurrence.*

Moreover, he added that a stable workforce was an important enhancer of Relational Internal SCI:

> *You lose those relationships and understanding and you lose much of your capacity to recover rapidly and return to normal operations. We've had a very stable SC team, a very stable merchant team, so we know all of these things … Collectively, we all come up with a plan on how to recover.*

The SC manager reported that the firm's supplier had no interest in supporting resilience building:

> *Generally, they don't want to know about it. It's not their problem. They don't want to know about it they would say.*

This was because the DAO had ordered stock in advance and the supplier was aware that the DAO was experienced and the *Recovery* stage was not usually prolonged.

The *Recovery* stage also required Informational and Operational SCI with T&L service providers; the latter needing to work closely and coordinate their actions with the DAO. The willingness and ability to support the DAO during recovery and affect SCRES building of the entire SC, justified building a good relationship with the T&L firm prior to the event:

> *I guess this comes down to the fact that we chose to build long-term, sustainable relationships with larger companies. We could have gone with cheaper, smaller companies, but these events hurt us. We use [transport company name], which is obviously one of the largest 3PLs in Asia Pacific because we have a longstanding business relationship with them.*

After two weeks, the complete SC-M2 was fully recovered and operating with regular capacity in regular manner.

The interviewee described the *Mitigation* stage as a continuous learning experience:

> *It's being proactive, building the plans, testing the plans, and then when you do get these events, execute them, and then come back with the learnings of those events so that you improve upon it each time.*

He added that Informational Internal SCI is important for *Mitigation* in terms of knowledge exchange and locking knowledge within the institution as Operational Internal SCI, because teams need to come together to rehearse and apply that knowledge:

> *Typically, what we do with new stores is train them while setting and we get better, and better, and better at it every time.*

Finally, the interviewee stressed that Informational and Operational SCI Internally helped the *Mitigation* stage, and had transformed their plans from a previously low, reactive, panicky mode to a well-planned and prepared system that was highly effective at responding to natural disasters.

TC Marcia 3—White Goods SC-M3

The SC-M3 is a white goods SC and the interviewee came from a company that wholesales for an overseas manufacturing company and supplies retailers all over Queensland. One regional hub was directly affected by the natural disaster by a number of local retailers being inundated, which forced the hub closure. Three days after the direct effect, the wholesaler was able to restart partial operations in the affected hub, which reached full recovery three weeks after the initial impact.

Most of the company's sales were completed after recovery, as planned; however, the financial impact estimates ranged from AUD3 to 5 million in delayed profit. The interviewee was reluctant to provide an exact estimation of financial losses, and instead chose to focus on how possible losses were reduced. The total financial impact was later estimated to be between AUD1 and 3 million, as the company ended up profiting more than expected in the aftermath of TC Marcia due to increased sales, as customers had to replace their appliances.

Customers, retailers, wholesaler and the infrastructure linking them were directly affected. The impact was transferred upstream in SC-M3 on the manufacturer in the form of delayed orders and changes to the content and volume of orders. There was also an indirect effect, as stores that were not inundated were impacted by the regional hub not being able to supply them with products. Conversely, stores supplied by other hubs were unaffected. There is no evidence that Marcia's effect was felt further upstream in the SC (see Figure 4-21).

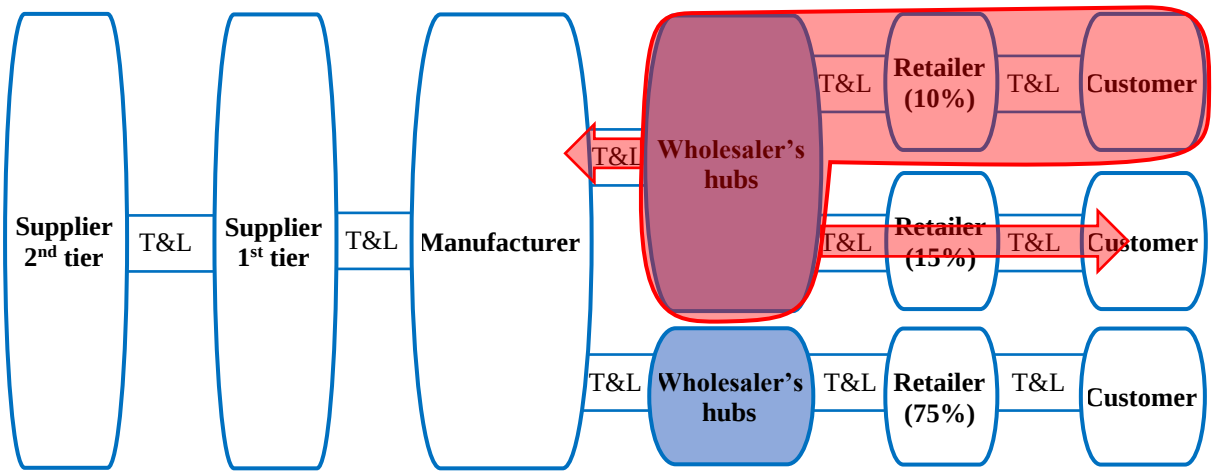


***Figure 4-21**: Graphical representation SC-M3 and effect of natural disaster on it*

The SC manager explained that the direct impact of the natural disaster involved closing the warehouse for three days, but the indirect impact existed longer, as the majority of roads were not available until three weeks after initial impact. This was the reason the SC and customers needed three weeks to fully recover.

The interviewee observed that an emergency team and plans existed as part of the *Preparation* stage—'*We have a team charged for emergency situations and we have planned in advance so we know what to do in these situations'*. In addition, he explained that the company anticipates cyclones and understands their likely effect—'*We see cyclones nearly every year and we take them seriously, that means we make sure we understand where our stock is'*. Further, the interviewee described how Informational and Operational Internal SCI were used to support the *Preparation* stage—*You need to know those preparations plans; people need to be aware of them and be rehearsed in them*. Notably, past experience has prepared the interviewee for future crisis; however, the firm is also aware that reliance on past experiences can be problematic. This is evident in discussion of the *Initial Response* stage, when the interviewee explained that management strove to gain an early warning of the direction and magnitude of a threatening cyclone and did not merely rely on what had occurred in the past. Based on these evaluations they respond accordingly and, if necessary, ship opportunistically:

> *When we got confirmation, and we knew the severity, that it was going to have a high impact to our business, we continued to ship while it was safe to do so, to safeguard any damage to our product, but also to try and recognise as much revenue as we could. Once we knew more details about when the cyclone was going to hit, we then stopped*

> *physically shipping to those locations, but we continued to process our orders. Behind that was our knowledge that we would recover quickly if we were loading the trucks, once it was safe to do so, even though they could not be despatched.*

The interviewee explained that all operations ceased in areas predicted to be affected one day before the expected direct impact.

After engaging in Opportunistic Operations in the form of shipping, the company closed one of the hubs in a directly affected area. During the *Initial Response* stage, the interviewee described Informational and Operational Internal SCI and Operational SCI with T&L provider as vital:

> *So, internal communications were critical. Being able to have full visibility of all of our orders exactly where they are, how much they were worth, is critical* .

Communication with governmental weather agencies was described as one-way communication during the *Initial Response* stage in the form of receiving weather forecasts. The interviewee indicated that he did not find it necessary to contact the BOM because he had a high level of trust in the forecasts.

When safety warnings were lifted, an increased number of employees were engaged to determine the extent of the damage and clear the site, thereby engaging Informational and Operational SCI internally. Both these forms of SCI were also engaged with T&L providers during the *Reconstruction* stage:

> *When it was safe to come back to work, we work very closely with the transport company to let them know what extra capacity, extra people, extra trucks are needed. We undertook a full financial assessment on that. Depending on our estimates of the damage we would determine how to recover and start delivering again to affected stores.*

The *Recovery* stage began by restarting operations, which called for a high level of Informational SCI, as it was necessary to determine if alternative routes should be utilised—'*Instead of going up by the coast, we got trucks to go inland'*. Informational Internal SCI engaged upstream and downstream communication within the company, while Operational Internal SCI involved multiple departments coming together to create a plan and evaluate damage. The interviewee also indicated close relationships were important during the *Initial Response* and *Recovery* stages, and repeatedly referred to all company departments as '*we'* and '*our'*:

> *Our management of these incidents and our quick recovery is not an accident. It's because in the past we've had problems, we put in contingencies, we have planned and*

> *we know how to do this. And so, when a cyclone or anything of that nature happens, we automatically go into a war room phase, we go into planning, we go into strategy together, we go into contingencies. Those things are part of what we do.*

Discussion of the *Recovery* stage included a description of Informational SCI with buyers, where buyers are referred to as retailers who sell products from the warehouse, and updating and advising them is considered integration. By contrast, Informational SCI with suppliers was only mentioned in passing, when it was observed that it was necessary to notify suppliers overseas about their recovery process and increase orders for products that experience led them to believe would be in increased demand once the crisis had passed.

The importance of SCI with the T&L provider was emphasised during the *Initial Response* stages. The interviewee stressed the importance of communication and building strong relationships with T&L service providers, as these linkages remained crucial until full recovery was achieved. The interviewee advised that constant communication with the government in relation to transport routes' availability and coordination of goods on the roads was also vital during the *Recovery* stage. Displaying a high level of trust in this advice, they planned their routes accordingly.

The *Mitigation* stage was described as constant learning. The interviewee repeatedly brought learning and improvement of existing plans into the discussion, indicating that *Mitigation* is conducted with the strong support of Information and Operational Internal SCI of teams who join together, share learnings and coordinate actions.

TC Marcia 4—Retail–T&L courier SC-M4

The retail SC-M4 is described from the position of the T&L courier company that transports goods from retailers to direct customers. T&L's company hub is located in Brisbane and while mainly focused on the Brisbane area, it operates throughout Queensland.

The company's main hub was not affected by winds or flood; however, smaller representative offices, collection point locations and vehicles in the field were inundated; therefore, T&L was analysed as a DAO. One part of the downstream SC had customers and locations of offices affected, and that effect was transferred upstream to the retailer. One part of the SC had only one hub inundated and vehicles trapped in the flood; therefore, the indirect effect was transferred downstream to customers and upstream to retailers. The third part of the SC had its infrastructure severed, causing an upstream and downstream effect on retailers, T&L company and customers (see Figure 4-22). SC-M4 courier company had to alter its operations

to avoid flooded areas where possible, and operations were reduced because some drivers were unable to reach destinations.

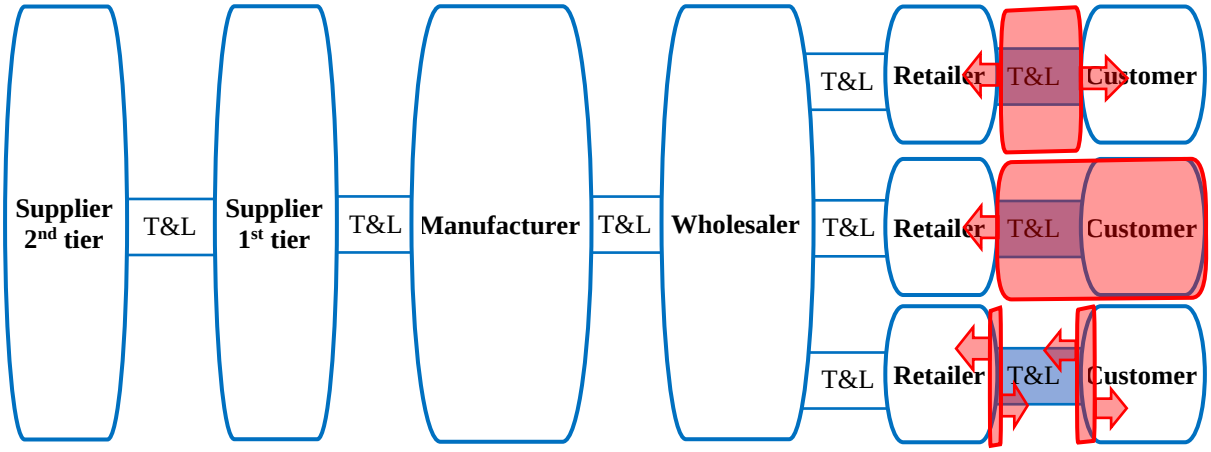


***Figure 4-22**: Graphical representation SC-M4 and effect of natural disaster on it*

The DAO stopped operations for 12 hours, and then continued by utilising an alternative operation mode with reduced capacity until full capacity was reached after four days. The DAO's suffered financial losses of AUD120,000. Other financial losses caused by altered and reduced operations were not calculated, but the interviewee assumed they were not significant.

In the discussion of the *Preparation* stage, the interviewee did not identify whether they had a dedicated emergency team, but did refer to a team that was directing existing plans. This suggests that planning is part of the firm's operation, but in the Queensland context, where cyclones are common, it is so effectively institutionalised that the notion of a dedicated team goes without mention.

When discussing the *Initial Response* stage, the interviewee explained that the DAO was aware of TC Marcia three days in advance. At that point in time, they started establishing safety procedures, exchanging information and coordinating their activities with emergency services:

> *Typically, you're either engaged by emergency services, or it's relying on you to read the papers, and be across these extreme weather events, but, for us, they're more than an informed process.*

The interviewee described staff meeting with emergency services to ensure community safety:

> *Basically, the approach to doing that was liaising with emergency services. Liaising with the BOM to determine which of the areas we needed to focus on putting controls in place to ensure people were safe.*

Offices in those areas were closed down and employees' safety ensured. In brief, the interviewee described Operational Internal SCI in terms of employees joining their efforts in a common goal to conduct estimations and ensure safety, and Informational Internal SCI downwards, upwards and between different departments in the organisation:

> *There's communicating to the drivers … We're relying on drivers feeding that information back … Then I spoke to what were the broader communications across that part of the business, across the processing, or transport.*

The interviewee added Relational Internal SCI and trust in the accuracy of information is important for building trust between actors, and is beneficial for SCRES building:

> *It is important to communicate with the other areas of the business to ensure that there's a consistent message, consistent messaging ensures trust, between people and across the organisation.*

The *Reconstruction* stage started by reopening offices and cleaning and refurbishing premises. Once again, Internal Informational and Operational SCI were deemed important. During *Reconstruction,* preparation of sites in ways that enabled the firm to conduct the *Recovery* stage effectively proved inadequate. The interviewee observed that Informational Internal SCI was not strong enough to support recovery because there were difficulties in information exchange upwards, downwards and between departments:

> *Communication was based on daily emails where a driver would call his network manager and tell him, 'there is a flood here. I cannot reach this street or this corner'. Then the manager would type an email and try to share it, but it was too slow because managers were not writing emails immediately, obviously. Then the other managers were not watching their emails all the time so they wouldn't see the information on time. Information was repeated here and there et cetera. The reporting back was really difficult.*

The interviewee added that difficulties in upwards communication were the main reason for financial losses, because drivers were not provided information in a timely manner and consequently tried to drive through flood. This raised the question of why the situation had not been corrected, given the firm's substantial experience with cyclones. The interviewee advised that it was because the bureaucratic structure within the organisation made reform difficult, as no driver in the past had been killed or experienced costs sufficient to motivate the bureaucracy to initiate reform.

The *Recovery* stage entailed reopening the offices that had been closed. Here, Informational Internal SCI was deemed important in terms of communication upwards and between company sectors, as was trust between departments and employees:

> *We needed to come together, to communicate openly and frequently, to engage effort and here trust is vital for achieving the best outcome, to trust each other's competencies and word.*

The interviewee also advised that Informational SCI with buyers and regular updating on operations was fundamental to reconstruction and recovery—'*Clients deemed this important and sustained constant communication with local transport managers'*. This process proved effective because experience had taught the T&L firm and directly affected customers that they could rely on the information provided. Indeed, it was observed that experience had generated a mutual understanding between the DAO and commercial and private clients:

> *We were not having significant issues with larger clients because we had a mutual understanding of what needed to be done by both sides.*

The interviewee described the *Mitigation* stage as entailing gathering department staff to discuss possible improvements where Informational Internal SCI had proven problematic—'*After we recovered, we gather and discuss what can we do better'*. The interviewee believed this exchange of information is important, but noted that the process had not led to improvements in information sharing between the centre and drivers, which has the potential to put the drivers' lives at risk and is a matter of concern.

4.3.6 Flood in WA (2017)

In January and February 2017, heavy rain and flooding occurred in southwest WA, inducing the government to declare the area a disaster zone (BOM, 2017b). Average temperatures were at record lows and rainfall at record highs (Powell, 2017). Severe floods took two lives (AIDR, 2018) and significantly impacted infrastructure and agriculture (BOM, 2017c).

Heavy rains began at the end of January 2017 in the Kimberley and Pilbara region, causing an overflow in the Avon River, Swan River and Blackwood River catchments (SEMC, 2017). In some areas, the rain did not stop for six days (BOM, 2017c; McHale & Perpitch, 2017), damaging roads and infrastructure and reaching the Esperance coast (BOM, 2017c). The heaviest rainfall was in areas of strategic importance to local infrastructure, including the Karratha Airport (AIDR, 2018) and Perth, which received over 25 times its average February

rainfall overnight on 9–10 February (McHale & Perpitch, 2017). By 11 February, the majority of roads in the area were closed (Powell, 2017).

By 15 February, four major railways were affected by heavy rainfall and flooding. The interstate rail connecting the west and east coasts of Australia was damaged and non-operational. Repairs were hindered by damaged roads (over 840 km) and other infrastructure (Probert, 2017). Eastern Goldfields Railway was closed (from Perth to Kalgoorlie and on to the eastern states), along with Great Southern Railway (from Northam to Albany), grain freight rail network (in the northern Wheatbelt and the Lakes District), and the Leonora line (from Kalgoorlie to Leonora) (Probert, 2017). Damage to infrastructure was estimated at AUD20 million (Bennet, 2017).

Due to the WA floods severely affecting the rail system, multiple SCs were disrupted. One of these is the food SC-W1, which is examined in this study. To visually represent the effect of these floods on the food SCs operating from WA to other states, the author has developed a map, presented in Figure 4-23 (adapted from BOM, 2017b; DIRDC, 2015).

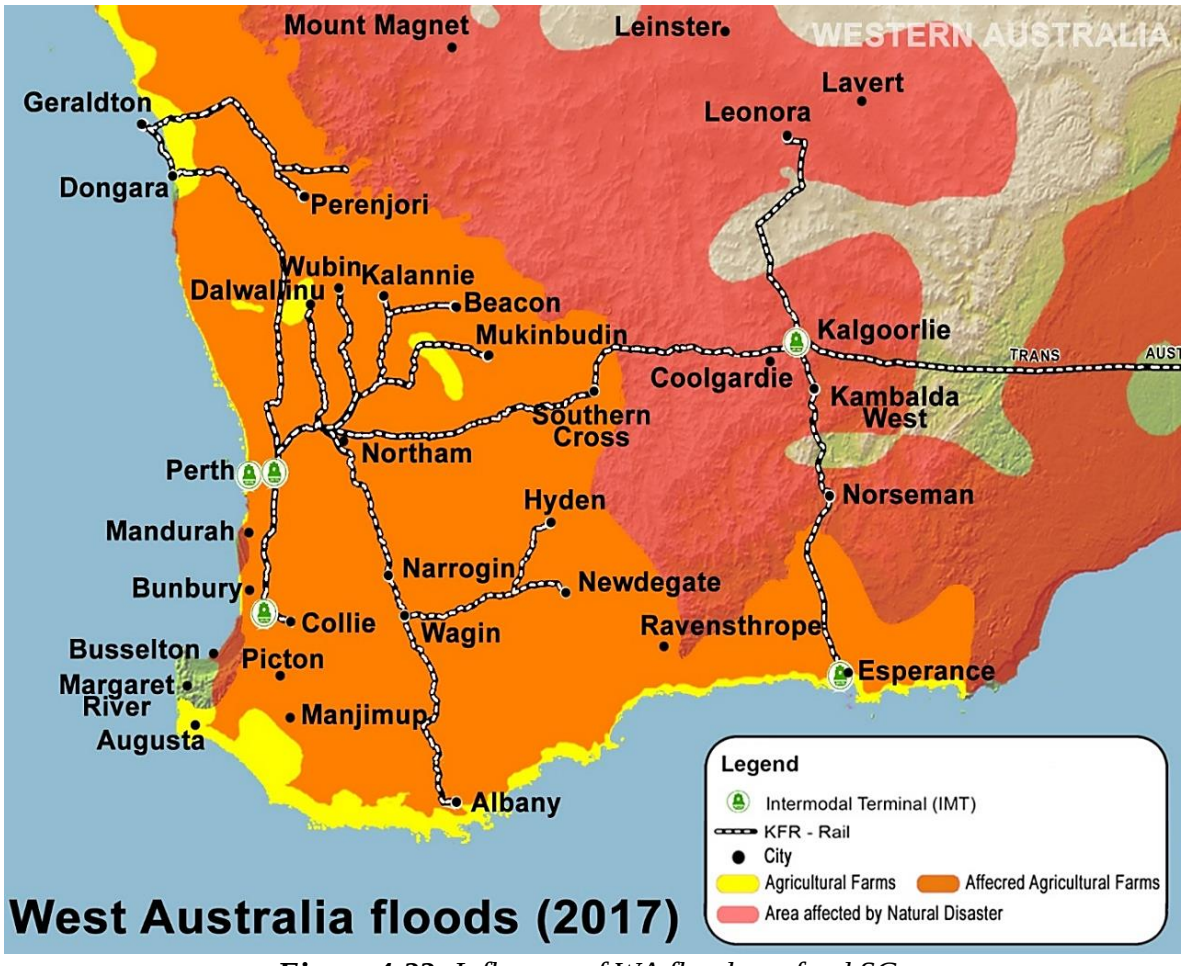


***Figure 4-23**: Influence of WA floods on food SCs*

WA floods – Food SC-W1

The interviewee from SC-W1 commented from the position of a manufacturer in a food SC that supplied major supermarkets in Australia. The interviewee's facilities were in Victoria and several chilled containers carrying meat from his supplier were trapped on the rail lines in WA. The interviewee's supplier was a farmer in WA and their farms were not directly affected, although many other farms were. For the manufacturer, having trapped stock meant a significant amount of supply did not reach their company and they were unable to provide supermarkets with the agreed amount of product; therefore, a substantial downstream indirect effect occurred (see Figure 4-24).

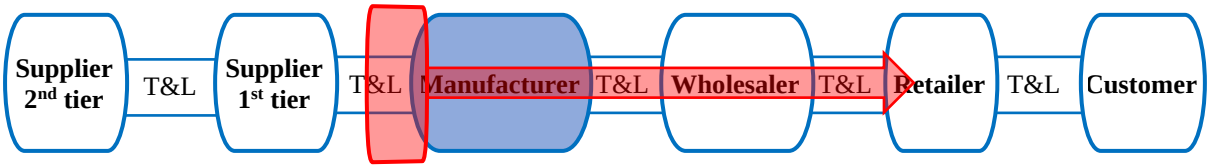


***Figure 4-24**: Graphical representation SC-W1 and effect of natural disaster on it*

Due to the perishable nature of the product, all trapped supply had to be disposed of. This significantly impacted the manufacturer who owned these goods; hence, the manufacturing company was analysed as a DAO. Indeed, the DAO was both directly affected by supply loss and indirectly affected due to extended period for the rail system to recover and the subsequent need to utilise more expensive road transport. Loss of supplies caused financial losses of AUD1 million and utilisation of road transport cost an additional AUD500,000.

Given the perishable nature of the firm's product, in the discussion of the *Preparation* stage, the interviewee observed the firm had planned how to address major disruptions to its distribution network and had a dedicated team committed to this task:

> *The team consisted of sales, warehouse, transport, marketing, all sectors and we had had emergency plans and recovery plans in place.*

He elaborated by reporting that they had identified alternative suppliers to turn to in an emergency, which underscored the link between Informational and Operational Internal SCI. Importantly, the firm had created simulations and rehearsed how to respond to crises, and both steps were considered a significant part of their resilience agenda. Notably, although this process was identified by the author in other case firms, how simulations are constructed and rehearsed has not been analysed by scholars.

The interviewee described the *Initial Response* stage as mobilising the emergency team to establish control and select the strategy to be engaged. As the storm did not directly strike the DAO's location, it did not have to initiate safety procedures or undertake a *Reconstruction* stage directed at repairing plant or equipment. Therefore, the DAO immediately went to the *Recovery* stage. The interviewee described Informational Internal SCI as supporting SCRES building at this stage in terms of communication downwards in the organisation:

> *Each emergency team member at the department level was responsible for ensuring communications from the crisis team were competently distributed to the staff in the sectors they were managing. Teams need to be coordinated and quick to react during a crisis, and they need to trust those with whom they are expected to cooperate until they reach full recovery, until it all becomes normal again.*

The interviewee also emphasised that Relational Internal SCI was important at these times in terms of trust, and Relational Internal SCI supported Operational Internal SCI and faster recovery—'*Fast coordination is not possible without trust'.*

Informational SCI with buyers was discussed as important during the *Recovery* stage, through regular updates with the company's buyers. The interviewee advised that this had not previously been actioned. In addition, he explained that Informational SCI was utilised to support Relational SCI with buyers, and the interviewee's company had invested additional resources to support buyers and address the previously existing lack of trust:

> *We needed to inform them regularly. Previously they haven't trusted us a lot. When we improved communication and allowed them to track our activity and updated them regularly, when we invested in more expensive transport to support them, we showed them we are worthy of their trust and stronger relationship was built.*

This also implies that the interviewee's company had to invest additional resources in supporting buyers and avoid them finding alternative suppliers or losing already weak trust in the DAO's ability to address the flood.

Constant communication with public organisations existed, which in this case centred on the rail maintenance organisation during both the *Initial Response* and the *Recovery* stages. At first this entailed gaining information on the extent of the damage, whether their stock would have to be abandoned, and how long it would take for the railways to become sufficiently operational to begin shipping their product.

The *Recovery* stage was explained as entailing the purchase of alternative transport to utilised while waiting for the railways to recover, which took two weeks. The interviewee described Informational Internal SCI as important during the recovery stage, underscored its

role in sustaining Relational Internal SCI, and notably stressed that the crisis had enhanced the firm's understanding of permanent employees; that is, 'labour hoarding':

> *Internal integration was really important during the process. Before the event there was a moderate level of integration, but during the event we actually realised that change in the staff was damaging our mutual understanding. We recognised the importance of long-term employees and of internal inter-sector communication and relationships.*

Considering SCI with suppliers, the interviewee expressed some level of disappointment with this relationship—*Our supplier was not affected. They send us their goods ... so they didn't really care*. Here, the interviewee appears to misstate the situation, as the supplier would have been affected in a positive way, as the firm would need to purchase more stock to replace the goods that had been disposed of.

The *Mitigation* stage included team meetings and implementation of a learning process. The interviewee explained that Internal Informational, Operational and Relational SCI were recognised as crucial during a crisis, and the company sought to build the experience into their planning and simulation activities, and consciously determine what the lessons learned implied for SCRES building during the *Initial Response* and the *Recovery* stages:

> *All sectors internally, would meet only fortnightly, sometimes even just twice a year before the extreme event. After that we started meeting more often. We recognised to a greater extent the importance of our integration, of coordination, of building understanding.*

The interviewee also described working on Informational and Relational SCI with buyers during the *Mitigation* and the *Preparation* stages through improved communication frequency and quality to build stronger relationships and longer cooperation orientation:

> *Because of better communication they felt more secure with us, they wanted to continue to cooperate after this flood, and long after it.*

4.3.7 Tropical Cyclone Debbie (2017)

On 28 March 2017, TC Debbie made landfall with winds of 265 km/h near Airlie Beach, about 900 km north of Brisbane (BOM, 2018; IGEM, 2017). It progressed inland, losing intensity and becoming a tropical low as it approached NSW (AIDR, 2018).

TC Debbie impacted the area in three ways between 28 March and 5 April 2017 (Aon Benfield, 2017). Initial strong winds and rain caused damage; then, unexpected rapid flooding occurred in southeast QLD, including Brisbane, the Gold Coast and southern Queensland from

the shore to 150 km inland (AIDR, 2018). Finally, slowly rising water levels caused flooding in central Queensland, days after Debbie made landfall (IGEM, 2017).

Most of the damage occurred in south Queensland and northern NSW. Properties and vehicles were damaged, airports were closed and infrastructure was severely impacted, with over 7,000 landlines severed, over 170,000 properties left without power, and several highways, roads and bridges closed and destroyed in the flood (Cyclone Debbie: Northern NSW residents urged to evacuate, 2017; IGEM, 2017).

The Australian Retailers Association warned that retail had been severely affected and supermarket shortages and increased prices may occur, as farmers had been severely affected and crops destroyed (Haynes, 2017). By the end of April, infrastructure damage was estimated at AUD2 million, Whitsundays tourism had lost AUD120–180 million, and the damage to public and private properties was over AUD2 billion (Lenzen et al., 2019; Tapim, 2017). The ICA received 58,000 claims by October 2017, valued at AUD1.4 billion (IGEM, 2017). This amount of damage created additional complications for insured properties because insurance reimbursements were delayed, which hindered the recovery of communities and businesses (Moody, 2018).

Some of the severely affected industries were retail enterprises and those that rely on rail transport and the purchasing power of the community; notably, the automotive sector. The effect TC Debbie had on these industries is presented in Figure 4-25 (adapted from BOM, 2018; DIRDC, 2015).

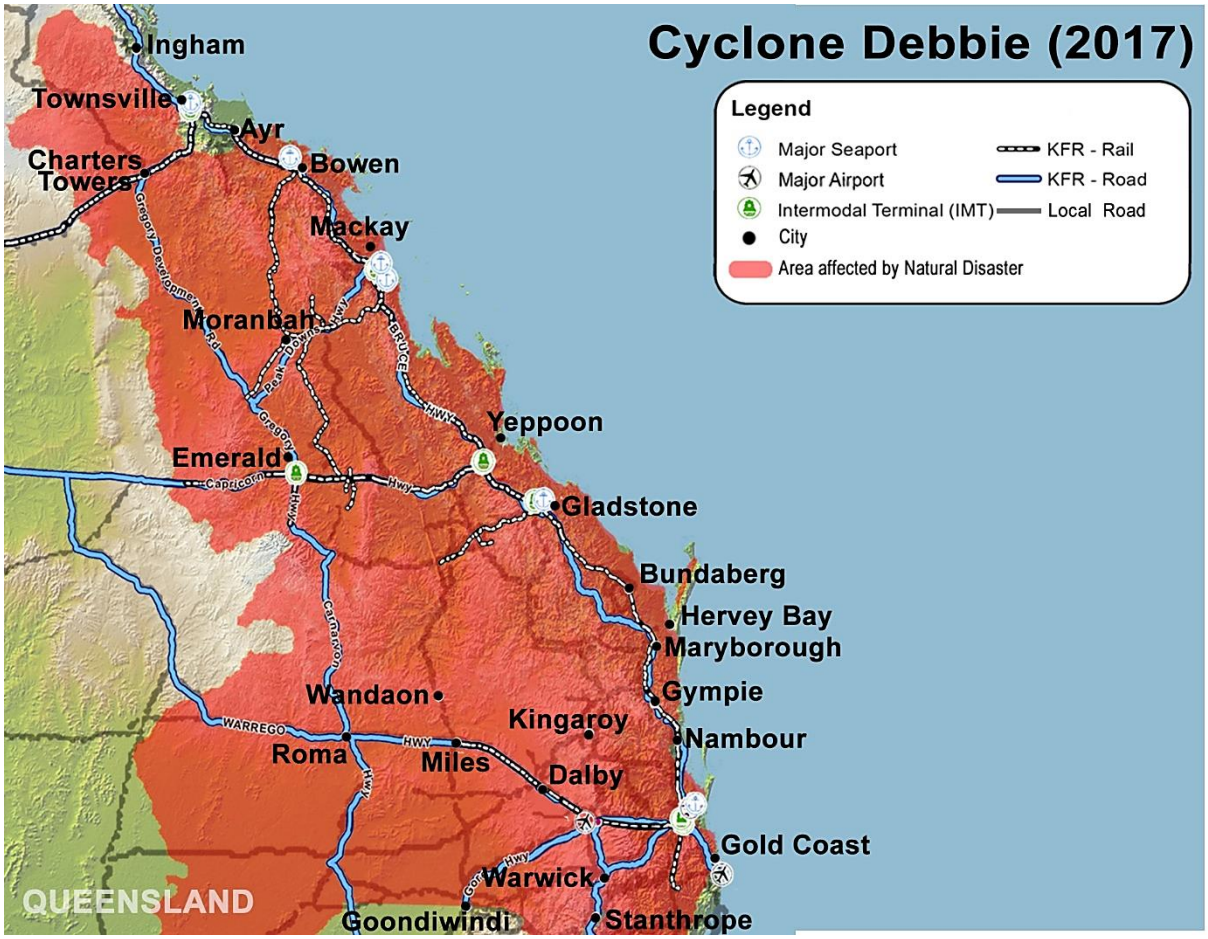


***Figure 4-25**: Influence of TC Debbie on retail SCs*

TC Debbie 1—T&L in automotive SC-D1

The interviewee from SC-D1 spoke from the position of a DAO that is a T&L service provider operating between a manufacturer and wholesaler in an automotive SC. The interviewee's company and trucks were directly affected by rainfall and flood, which resulted in a complete halt to operations for one week and full recovery after seven months.

The interviewee explained that the direct effect of TC Debbie on their business included inundation of facilities and the consequent need to renovate the hub in terms of carpets, furniture and electronic equipment, as well as vehicles replacement. He advised that the first goal was to restart operations in any capacity as soon as possible, and then build capacity to restore operations to what they had been before the disaster.

The indirect effect on the DAO occurred due to the railway network being affected and roads inaccessible. However, even after the roads were safe and accessible, the DAO was not able to operate in full capacity until all facilities were renovated. This meant the indirect impact did not cause delay in the recovery.

The SC manager stated that both his and his buyers' finances were impacted significantly. He felt pressured to assist those most impacted, and found those not prioritised were generally understanding. He added that the upstream effect indirectly reached the manufacturer, but was unable to comment on whether TC Debbie impacted firms further up the SC. Since the entire area was flooded, the direct effect of TC Debbie impacted wholesalers, retailers and consumers.

A few buyers were not affected directly by TC Debbie but were indirectly impacted because the DAO could not deliver their needs. In addition, some directly affected buyers had customers that were not affected. This dictated different relationships occurring with different buyers of the T&L DAO, depending on the pressure and demand they felt from their buyers. A comprehensive representation of the structure of the SC-D1 and effect of TC Debbie on this SC is presented in Figure 4-26.

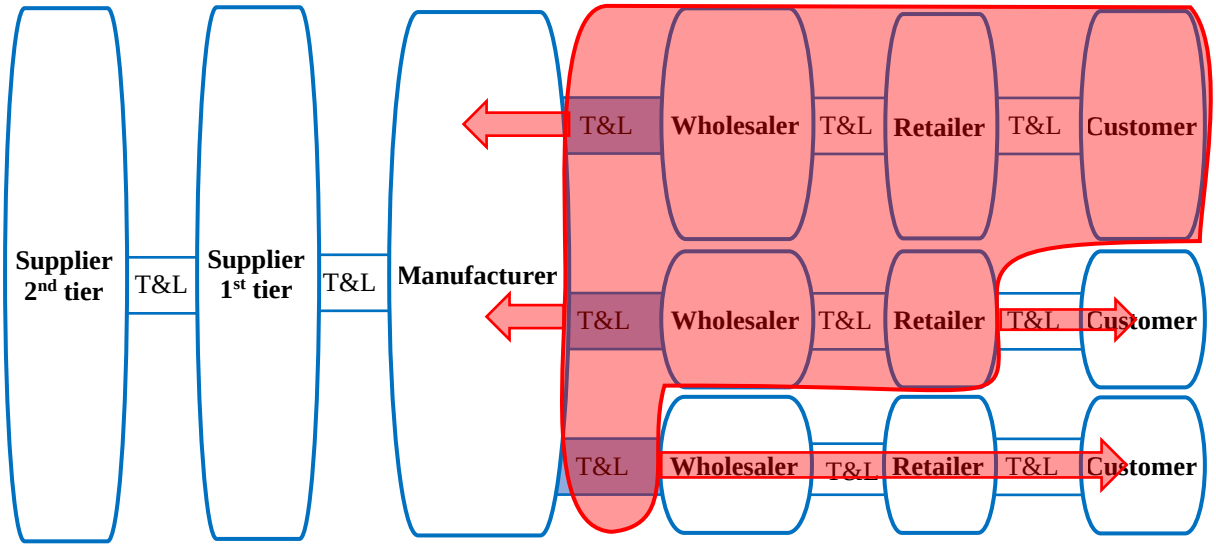


***Figure 4-26**: Graphical representation SC-D1 and effect of natural disaster on it*

In the discussion of the *Preparation* stage, the interviewee referred to the emergency grouping as the '*executive leadership team'* and described the multiple plans the company uses to respond to natural disasters. He also detailed the nature of the Informational SCI the firm maintains with buyers, which aims to keep them informed of plans for sustained resilience and seeks information from buyers regarding their plans to facilitate the coordination of effort:

> *When we onboard customers, we go through disaster management planning. We have our internal checklist of what we look for in sites and we find that many of customers also have plans in place to deal with perioding natural disasters. I think ourselves and*

> *our customers have moved on from where we were as a consequence and together we have established a more effective crisis strategy.*

The *Initial Response* stage entailed an initial evaluation of the transport vehicles' locations and routes. The interviewee explained that he had known about the possible impact of the natural disaster almost one week in advance, but decided to continue operations through that week as much as possible. Thus, the company focused on performing Opportunistic Operations by directing deliveries to where they would be most needed, securing buildings and halting deliveries to unsafe areas:

> *We used sandbagging, reinforcing windows. We use hail netting to cover the vehicles that are in our cost dock. Security, what we need to do there as far as securing the customers' products. Ensuring everybody's safe and that usually means a skeleton staff during the event. Everybody's sent home to look after themselves.*

When experiencing the direct impact of the disaster, the firm stopped operations in all affected areas and once the storm abated, an evaluation of the damage was immediately initiated. This assessment was conducted on everything likely to have been affected—'*Identify and assess damage both to your own asset base and to customers'*. Discussion of the *Initial Response* stage also included a description of Informational Internal SCI in terms of communication downwards and upward in the organisation, and particularly between management and truck drivers. Informational and Operational Internal SCI were described jointly in terms of communication and coordination between company sectors and between decision-makers.

> *We look at our trucks that are on the road, where they are, where they're going, they let us know, we make decisions.*

The interviewee underscored the need to clean and prepare the worksite in preparation for restarting operations, and judged this to be the part of the *Reconstruction* stage. These remedial actions continued when partial operations started, and the interviewee emphasised the importance of communication and coordination when evaluating damage and undertaking reconstruction:

> *Any remedial actions that we need to take as far as repairs, maintenance, upgrades, rebuilding requires information and coordination and entails securing vehicles, buildings and goods and determining what is to be done following the initial evaluation.*

Contacting buyers was the part of their business continuity plan. Initial contacts were made before the DAO was able to restart operations, during the *Reconstruction* stage, to evaluate urgent shipments. This Informational SCI with buyers continued through the *Recovery*

stage—'*That communication continues until we reach full recovery'*. The interviewee also described Informational Internal SCI in terms of increased frequency of emergency team meetings. Some contact with governmental weather agencies existed through receipt of weather forecasting and development notifications.

The *Recovery* stage was described as beginning when operations were restarted, even though this was done to a limited extent. The interviewee added that simultaneously remedial actions were initiated in the affected locations:

> *We were back operating in a very short period of time, like within a week, but getting it back up to like-for-like, post versus pre, was probably six, seven months by the time everything had been upgraded and this included re-cladding the walls, because the board had been rotted through.*

The interviewee described Informational Internal SCI as communication between company sectors and Operational Internal SCI through increased interaction and cooperation between sectors as beneficial for recovery. He also described Relational Internal SCI that took place during the *Recovery* stage, which was noted to support Operational Internal SCI:

> *The longer the relationship the better because the understanding with parties takes a period of time to establish. That certainly helps. Close working relationships across our business sectors. We were growing together, so that works as well. You very much look at cost division units supporting one of the units that's exposed.*

In addition, the interviewee described Relational Internal SCI as care for employees' psychological health during the *Reconstruction* and *Recovery* stages. He explained that Operational Internal SCI took place to further develop relationships, which involved the distribution of increased resources to bolster wellbeing:

> *HR was involved if there was anything that needed to be done including counselling people and examine personnel's resources and organise financial transfer where this was needed.*

Besides describing continued communication with buyers, the interviewee discussed Operational SCI with buyers in relation to the need for close cooperation on issues that are outside contracted services, by investing additional resources and deeming recovery as a joint effort:

> *We do look at working with the customer base for disaster recovery as well for solutions that are outside our scope on a contractual base.*

The interviewee also reported that different Relational SCI was forged with buyers because some had a deep understanding of what needed to be done and could be done, and some did

not. He explained that a key factor differentiating the two cohorts was how long cooperation had been sustained:

> *Some are in a long-term partnership with us and are very broad and collaborative in their approach. Others can be very hostile, extremely hostile, and claim that we should have done this, you should have done things differently, you should have done this, you should have done that.*

A further factor causing some buyers to be hostile was the pressure put on them by their buyers—'*If they're under pressure in the local market, they'll put pressure back onto us'*. He also explained that Relational SCI with buyers could have been utilised to support Operational SCI with buyers, and this would have been beneficial for restoring the entire SC—'*A relationship perspective is fundamental. Only if we work together do we all recover'*.

The *Mitigation* stage was described as learning from previous events and incorporating this knowledge into the company's practice and future plans by building facilities that are resilient to the type of natural disaster to which the area is prone. The interviewee also emphasised that Informational Internal SCI is critical to conducting these improvements and was engaged in a series of meetings designed to share knowledge:

> *When we're building or upgrading or maintaining our branches and sites, we look at what can be done or learn from previous sites. Flood control as far as roofing, draining, and the likes on roofing. Electricity, we've gone and installed on all new sites in the last three years have got either/or. In fact, on some we've got both wind and solar power generation. We go through those natural disaster management plans in the Initial Response stage and then that is basically gone through again after an event, in the Mitigation stage.*

In addition, Informational SCI entailed providing the new knowledge to buyers, which was described as knowledge sharing, with efforts made to gain feedback from buyers that would assist *Mitigation*, support Operational SCI, and assist the further maturation of plans for the future:

> *A lot of customers are quite reasonable in working with us and determining what's the best plan of action to try and mitigate any exposure for any future events. We work together on that.*

TC Debbie 2—Furniture manufacturing SC-D2

The interviewee from furniture SC-D2 spoke from the position of a manufacturer; however, the firm is a brand with its own warehouses that supply furniture stores. The furniture is sold directly to customers, and in this instance, one warehouse supplies five stores, of which three were flooded. As there is common ownership and the interviewee described

communication with stores and warehouse management as internal, and communication with customers purchasing in the stores were referred to as (external) buyers, the interviewee's company is analysed as DAO. In addition, the manufacturer does not ship furniture to any retailer other than their branded stores.

The interviewee was able to describe the direct effect of TC Debbie and reported that the associated prolonged floods affected the SC from customer to wholesaler, with an indirect upstream effect that reached manufacturing operations. However, the interviewee was not able to comment on further upstream effects (see Figure 4-27).

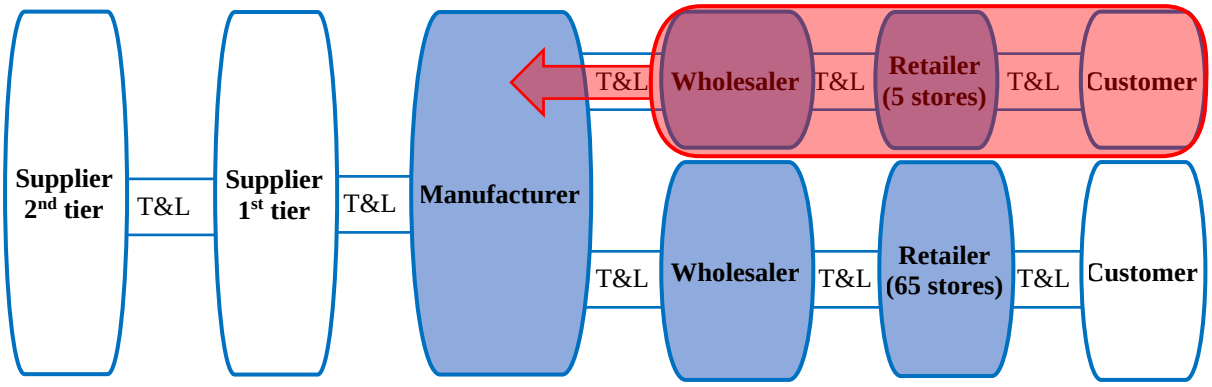


***Figure 4-27**: Graphical representation SC-D2 and effect of natural disaster on it*

The interviewee reported that directly affected locations needed four days to restart operations and the entire SC needed longer to reach full recovery, although he was unsure of the exact length of time. Financial damage was significant and the initial response focused on restarting operations and subsequently striving to reach full operations over time.

As part of the *Preparation* stage, the interviewee discussed the DAO's plans related to stock keeping. He observed that their planning accepted a senior team would be in charge of decision-making and communication during any crisis. As part of the *Preparation* stage, a substantial effort was made to build strong relationships with suppliers, T&L firms and buyers, and these were constantly reinforced during normal circumstances. This was deemed important because those relationships can be utilised to support SCRES building in later stages.

As part of the discussion on the *Initial Response* stage, the interviewee explained he was made aware TC Debbie was approaching two days before the initial direct effect occurred by the BOM:

> *It was a matter of days. Yeah, so we prepared as much as we could and then, I'd say, within two days all the damage started happening.*

Initially, the firm strove to secure goods and facilities—'*We needed to get the product up of the ground and elevated as much as possible'*—and we needed to ensure the safety of employees—'*Well, first things first is making sure everyone's safe'*. Securing goods and employees was supported by Internal Informational and Operational SCI, as instructions needed to be distributed and teams conducting operations mobilised.

After the direct effect of TC Debbie ceased, the damage was evaluated and strategies developed on how to progress reconstruction. Internal Informational SCI during the *Reconstruction* stage was utilised as regular and accurate communication upwards and downwards in the organisation was needed:

> *We made phone calls and emails to the senior team, and phone calls and emails to the stores to ensure we were transparent with everyone the whole time, but also strove to be honest with stores as this was very important.*

The interviewee also emphasised that Internal Operational SCI was utilised to support SCRES building by asking employees to increase their work effort; a task that was greatly assisted by the existing strong Internal Relational SCI:

> *We had a team that was willing and able to put in the hours when needed, to be able to turn things on quickly when needed, because our team was strong. So, we did have to work long hours in the warehouse but that wasn't an issue because we have such a strong team. Relationships were strong.*

Informational SCI with suppliers took the form of increased communication, joint efforts and coordination during the disruption. This was particularly important during the *Reconstruction* stage when orders had to be delayed until the site was prepared to receive them, and during the *Recovery* stage, when orders needed to be pushed:

> *So, in that circumstance, whenever we have issues, we are able to pick up the phone and say: 'Supplier, we're having an issue', or: 'Slow down these purchase orders'. We've not had an instance where that hasn't happened. And we had relationships with our suppliers where they'd given out POs well in advance … they do make and hold the product there locally, and then we draw on it as we need it.*

The relationship with the supplier was highly valued and the interviewee took an opportunity to emphasise this point several times in the discussion—'*We have really good relationships with our suppliers, really good'*.

Relational SCI with T&L service providers was based on long-term cooperation—'*We have long-term partnerships with transport providers, ranging from five to 25 years'*. Based

on this long cooperation, the interviewee's company received relevant support from T&L service providers during SCRES building.

Informational SCI with buyers was described both in relation to the *Reconstruction* and *Recovery* stages with the interviewee mentioning the need to provide updates and open communication about progress during these stages—'*It's just about managing the customer's expectations while you're recovering in your SC'*. Expanding on this comment, the interviewee discussed Relational SCI with buyers during both stages, explaining that buyers had sympathy and were willing to purchase other products the DAO was able to supply faster. This practice was supported by maintaining a high level of transparency—'*So, if something was delayed while being transparent everybody was informed that this was the case'*.

When inundated stores were cleaned but the warehouse remained inundated, the *Recovery* stage began and the interviewee observed that alternative ways of operating were initiated, including using containers as temporary storage facilities:

> *So, we took a stance to make sure that we sent product to the store once all the water had subsided in container form. And we held the container at the store so they could one, use the container as a portable warehouse until they recovered the warehouse. And then, once the warehouse was recovered, we were able to fill the warehouse back up with stock.*

Informational Internal SCI was described as frequent communication downwards, from management to store employees. The interviewee elaborated on open and honest communication to build Relational Internal SCI through understanding and trust, and that Relational Internal SCI supported Operational Internal SCI in the fast execution of plans and team coordination:

> *But it's all about showing them the support … just being open, transparent with stores. Having discussions and maintaining open and frank communication makes a really big difference in the way you execute any change.*

Transparency with suppliers was repeatedly mentioned as part of the discussion on the relevancy of Informational SCI. Further, the interviewee observed that strong relationships with suppliers supported joint effort and joint ownership of the concerns that arose:

> *I'd call it just the relationship, the partnership that we have, and we do work really well together. So, whenever we say there's an issue here, whatever, they're very accommodating … always work together to resolve the issue.*

The interviewee drew special attention to Relational SCI both within the company and with external stakeholders, explaining strong relationships as a pillar to building SCRES:

> *Without the strong relationships, your SC, your retail network, and everything you do, won't work … You will not recover, not on time, not on budget.*

The interviewee described the firm's relationship with the T&L service provider as important and stressed the significance of not putting too much pressure on any one provider or being too reliant on any one T&L service company. Therefore, the company hired multiple T&L service providers, and this had worked well in the past, even though it meant they might not be prioritised by any single T&L.

> *If you put too much pressure on one [T&L] provider, they're going to fail, and that's only going to cause problems for you. So, we'd rather spread the risk by having alternate suppliers.*

Discussing the *Mitigation* stage, the interviewee described improved planning related to stock keeping. As a result, the DAO opened multiple warehouses to support various stores in case one warehouse gets affected:

> *And the reason why we've opened [additional warehouses] in the last 12 months was to decentralise. So, we had one warehouse in Sydney and half a warehouse in Melbourne about 6 to 8 months ago. And now we have a warehouse in Sydney, Brisbane, Melbourne, and Perth just to do risk business. And also, if one warehouse is down, another warehouse can service the stores.*

This indicates that the interviewee's organisation actually enabled Opportunistic Operations in the case of the next natural disaster.

4.3.8 Typhoon Soudelor (2015)

Typhoon Soudelor, known in the Philippines as Typhoon Hanna, was the strongest storm in the 2015 Pacific typhoon season, with winds reaching 285 km/h. The estimated financial damage to the Mariana Islands, Philippines, Taiwan, South Korea, China and Japan reached above USD4 billion. Saipan city, Mariana Islands, was affected on 2 August 2015. In the following days, the weather system intensified and became a super typhoon as it approached the Philippines (Pama, 2015), and intensified further just before striking Taiwan (Pama, 2015). On 7 August 2015, SBS reported that even before reaching Taiwan, Typhoon Souledor killed two people at sea. Landfall occurred the following day (Enus, 2015).

The typhoon made landfall on the south-east coast of Taiwan, in Hualien County, on Saturday 8 August, local time (Straits Times, 2015). Aljazeera, reported that it became a category 3 storm, ripping up trees, breaking wind turbines in half and causing landslides in multiple areas of north Taiwan (Belling & Haylen, 2015; Pedrosa, 2015). In the affected area roofs were swept off buildings of large facilities, billboards were torn apart, and traffic lights

broke, injuring residents and damaging vehicles (Enus, Hollis, & Tsai, 2015). After 11 pm on 8 August, the typhoon finally left Taiwan territory, but for local residents and businesses, the catastrophe continued as heavy rains caused flash flooding and further landslides (Enus, Hollis et al., 2015).

This typhoon had the largest effect on infrastructure in Taiwan's history. Railways were closed (ENS, 2015), almost 430,000 buildings lost water supply, almost 65,000 properties were left without landlines (Fritz, 2015; Mullen & Narjarian, 2015), and millions of private and commercial buildings lost electricity (Mullen & Narjarian, 2015). Ports in Taiwan were closed and the entire fishing industry was interrupted (Belling & Haylen, 2015).

One of the SCs affected by Typhoon Soudelor was construction SC-TS1 that included steel producers from Taiwan and was examined in this study. To capture the influence of this disaster on SCs supplied by the steel industry in Taiwan, the author developed maps, which are presented in Figure 4-28 and Figure **4-29** (adapted from CIA, Esri, & Horner, 2013; Fakour et al., 2016; IVMH, 2016; Kao et al., 2019).

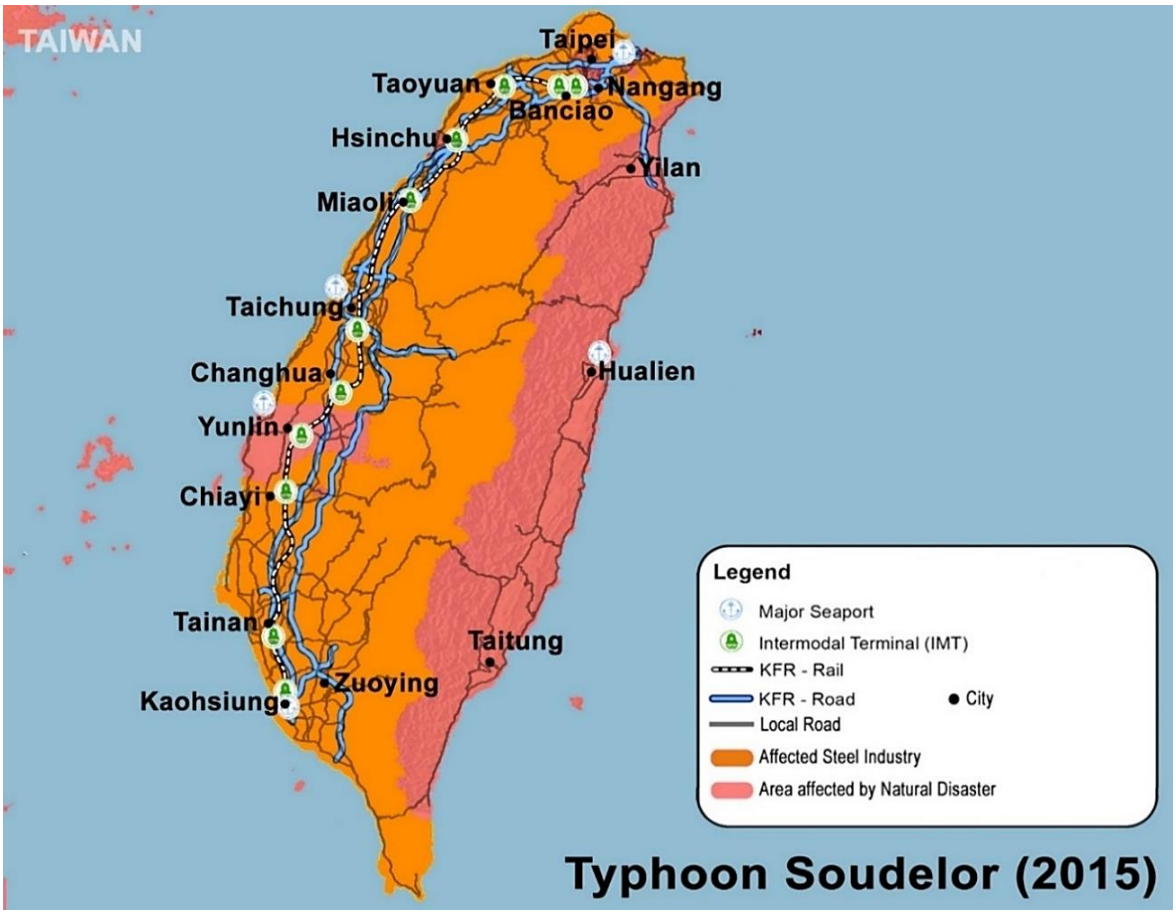


***Figure 4-28**: Influence of Typhoon Soudelor on SCs that use Taiwan steel suppliers*

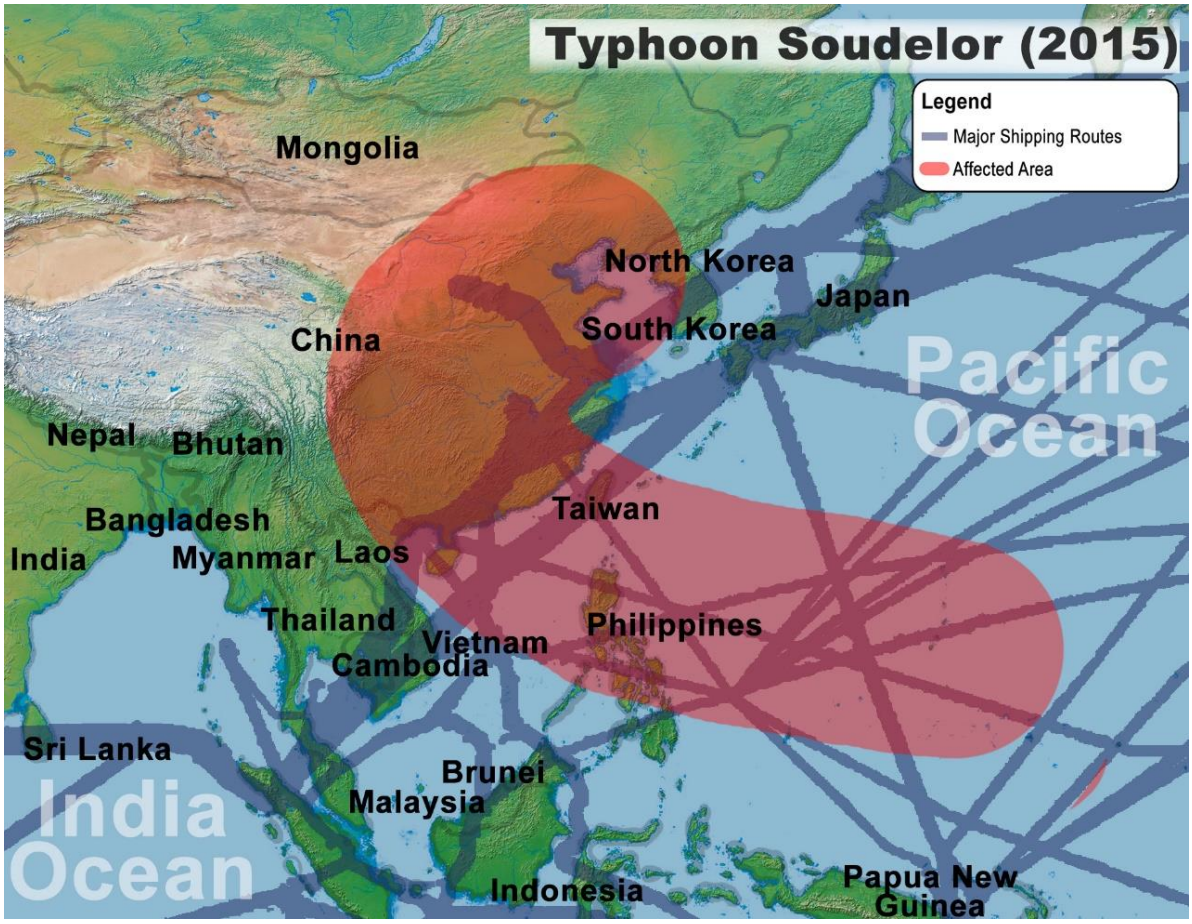


***Figure 4-29**: Influence of Typhoon Soudelor on international shipping lines*

Typhoon Soudelor—Construction SC-TS1

The SC-TS1 is a construction SC. The interviewee spoke from the position of a wholesaler located in Australia, whose supplier is a manufacturing organisation in Taiwan that was directly affected. Following an evacuation, the DAO needed four days to return to the site and start preparing to restart operations, which took 14 days before full capacity was reached. The interviewee's statements are coded from the position of a buyer from a DAO.

The advantage of interviewing an indirectly affected company is that the interviewee was able to explain the effect of a natural disaster on his firm and further downstream in the SC. Some second-tier suppliers and the majority of first-tier suppliers in TS1 were also affected, as their facilities were near the DAO. The interviewee commented from the position of the buyer of DAO and his company was indirectly affected only in terms of uncertainty of supply arriving before his stocks ran out. Other than that, this wholesale company did not report a significant reduction in its operations. Shipments from Taiwan were late, but that caused no financial damage to the indirectly affected wholesaler. Some operational disturbance existed in terms of increased orders from the wholesaler to its buyer after all supplies arrived. An

additional downstream indirect effect existed in terms of delayed product delivery to retailers; however, interviewed wholesaler was unable to identify whether the effect existed anywhere further in the SC. The structure of SC TS1 and the effect of Typhoon Soudelor on this SC is presented in Figure 4-30.

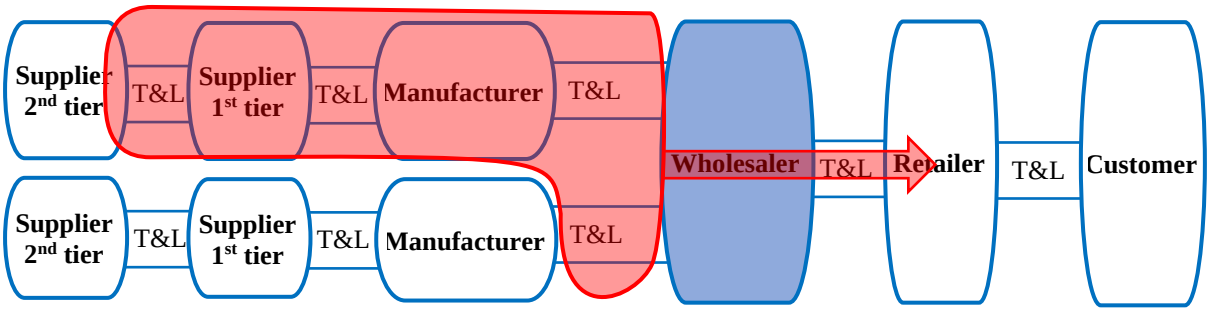


Figure 4-30: *Graphical representation SC-TS1 and effect of natural disaster on it.*

The interviewee explained that the DAO had preparation plans based on previous experience, which entailed purchasing extra supplies to buffer the effect of typhoons downstream in the SC:

> *We actually put in our system to have a bit of buffer stock during the typhoon season … to make sure in June, July through our September period … to actually compensate for the risk of typhoon without excessive the monetary impact.*

When describing the *Initial Response* stage, the interviewee observed that Informational SCI with buyers was needed and had to be sustained after the safety warning was lifted:

> *After extreme weather, normally we gain new insights ... I will not say we enter the epicentre to see their progress, but we basically gain an overview of how they recover and when they recover and that is basically based on a daily update.*

This communication continued through the *Reconstruction* and *Recovery* stages until full recovery is reached. The interviewee described initial Informational SCI with buyers as notification of possible disruption:

> *Normally when it's a warning coming up, they will tell us, 'Okay, they're gonna shut down for a few days because of extreme weather or the typhoon.'*

The interviewee explained that his company's *Initial Response* included waiting to determine the impact on the DAO. At this time, his company continued operations because they had enough supplies. The interviewee explained that the DAO was in constant contact with local government during the *Initial Response* stage to determine when they could return

from the evacuation and begin the *Reconstruction* stage to restart operations. As part of this process, they conveyed the following information:

> *Our subcontractor is unable to do a critical operation because of the flood. There has been damage to the machinery which has had to be shut down. Our production process uses burners, it's a heat treatment process, so when the machines shut down it actually takes at least four to five days to restart them again.*

Overall, the DAO needed seven days to restart operations and 14 days to fully recover. The interviewee added that Internal Informational and Operational SCI was utilised to support the *Reconstruction* stage in the DAO—'*I know they were coordinated, they needed to talk to organise all the actions'*. Informational SCI between the DAO and the buyer was described as involving feedback to the DAO regarding demand so its managers could adjust their production priorities during the *Recovery* stage:

> *We were helping them by letting them know which product would be in shortage and which product was okay to postpone.*

The interviewee explained that communication was utilised as a base to support Operational and Relational SCI between the DAO and buyer:

> *Just talk to your supplier, understand them and understand their process. Then you will find a strategy to overcome this issue together.*

He advised that a long-term association between buyer and supplier helped build strong relationships and insisted this was vital:

> *Very close relationships, true integration into each other is what is engaged with this model. I have worked with the supplier, the same supplier for more than 10 years.*

The interviewee also underscored the importance of Operational SCI between the DAO and first-tier buyers, and between first-tier and second-tier buyers:

> *It's a lot to do with close coordination and cooperation with the supplier and your customer in order to see to reduce the risks confronting both sides.*

He added that Relational SCI between first-tier and second-tier buyers was valued—'*Our customer was quite understanding about the situation … We were quite impressed by that'*. The interviewee expanded that this Relational SCI is based not only on long-term cooperation, but also on the nature of the construction industry's SC, which does not include fast-moving retail goods.

The interviewee's statements regarding Operational SCI between DAO and the interviewee's company were somewhat contradictory. While the interviewee clearly believed

Operational SCI existed in the SC involving teams working together during the *Recovery* stage, when describing the *Reconstruction* stage, he made it clear that there were severe limits on the support they were willing to accord the DAO:

> *Interviewer: Did they ever ask you for financial support during that time or for some other kind of support other than information?*
>
> *Interviewee: No. They can try, but will never get it!*

The interviewee reported that the *Mitigation* stage included implementing knowledge gained from experiencing typhoons and entailed new plans for stock buffering and Early Anticipation, based on their understanding that these storms were occurring with increased frequency and becoming more severe and complex to manage:

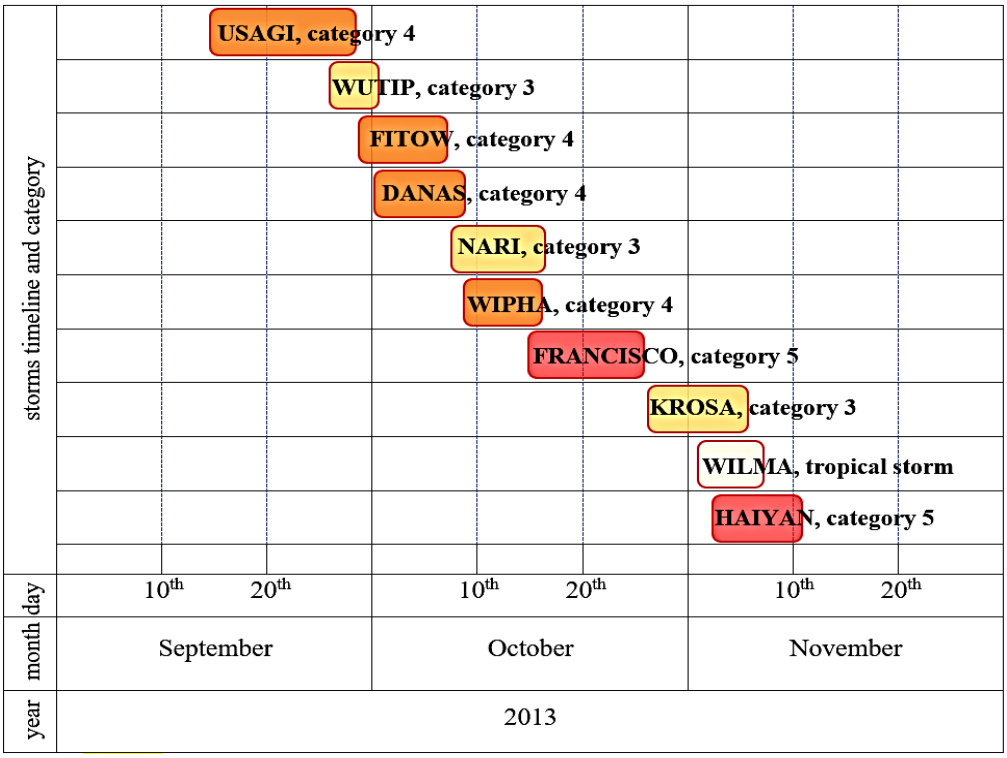
> *So, our buffer stock is gradually increasing just to make sure that we're able to cope with the challenge posed by the recent typhoon. Just to give you an example, five years ago, during the typhoon season, we increased buffer stock by 20% but recently we have decided we need to increase this to 50%. We just say to our supplier to send us stocks for four weeks, just to make sure we have enough to cover our risk.*

4.3.9 Pacific Ocean typhoon season 2013

The 2013 Pacific typhoon season was the costliest typhoon season recorded in the region up to that time. Total damages were estimated at USD25.75 billion (2013 USD) and 8,570 fatalities were recorded (2013 Pacific typhoon season, 2013). During the season, the region experienced 49 tropical depressions, 31 storms, 13 typhoons and five super typhoons. Winds started intensifying in June 2013 and storms became severe during August and September, reaching their peak at the end of September and throughout October 2013. November started with Typhoon Krosa and the region experienced one more major typhoon, Typhoon Haiyan, with winds finally dying down on 3 December (Aon Benfield, 2013).

From the end of September to the middle of November 2013, 10 powerful storms affected the west Pacific region, disrupting major shipping lanes between the Asian countries and the rest of the world. Starting with Typhoon Usagi (category 4), from 16 to 24 September Typhoon Wutip (category 3) overlapped with Typhoon Fitow (category 2), which overlapped with Typhoon Danas (category 4). Then Typhoon Nari (category 3) overlapped with Typhoon Wipha (category 4) and Super Typhoon Francisco (category 5) in October, and Typhoon Krosa (category 3) overlapped with tropical storm Wilma and Super Typhoon Haiyan (category 5) (GOVPH, 2013; Lea & Saunders, 2014). The consistent overlapping of these nine typhoons

and one tropical storm (see Figure 4-31) caused significant delays in international transport (Evans & Falvey, 2013).



Key: Category 5 , Category 4 , Category 3, and tropical storm

Figure 4-31*: Timeline of storms and typhoons in 2013 Typhoon season (adapted from Wikipedia.com)*

The area affected by the 2013 Pacific typhoon season (generated using the NOAA's online tool, www.coast.noaa.gov/hurricanes), reached across and had a significant effect on inter-Asian shipping lines and international shipping lines between Asia and Australia (CIA, et al., 2013). For the purpose of this study, the author developed a map of disrupted international shipping lines (see Figure 4-32).

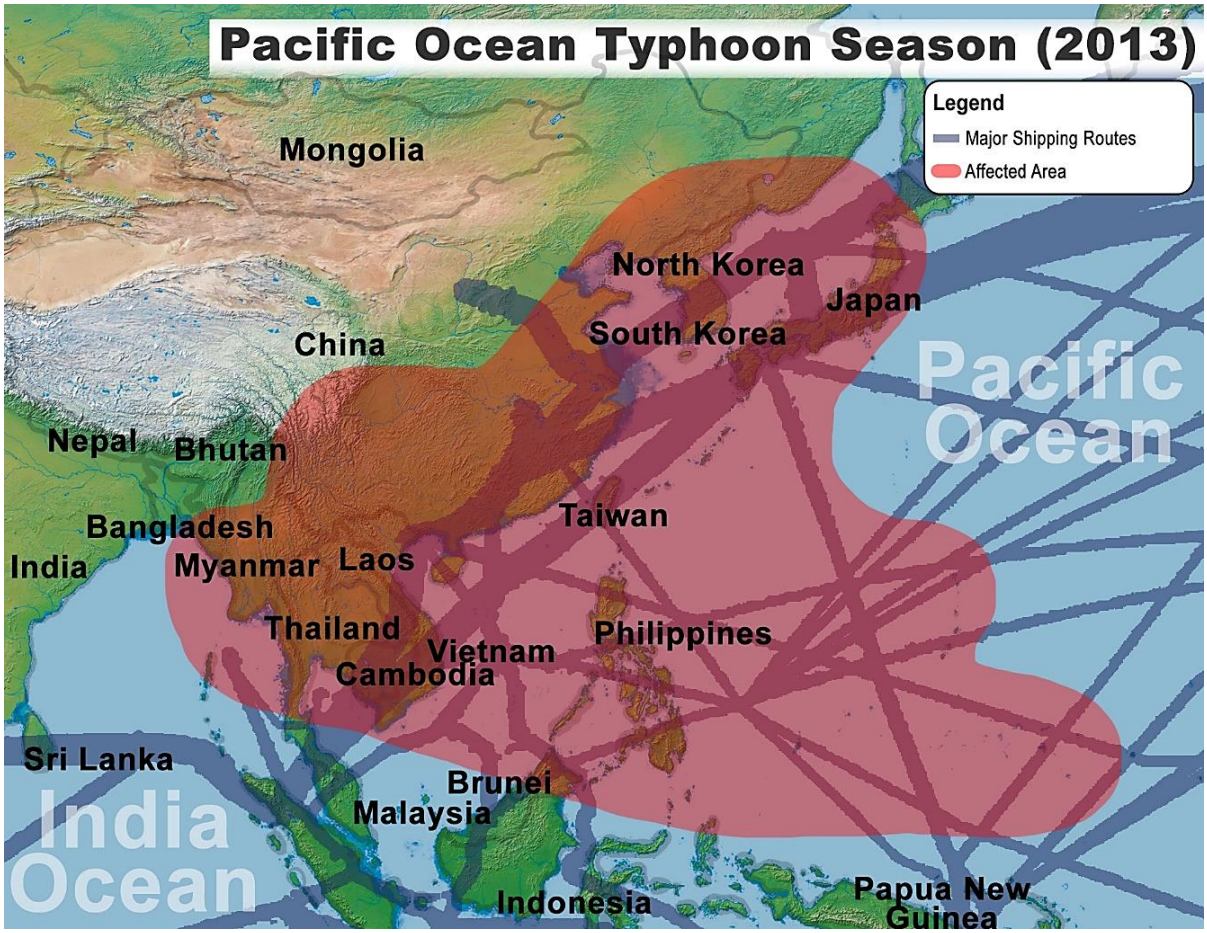


***Figure 4-32**: Influence of 2013 Typhoon season on international shipping lines*

Pacific Ocean typhoon season 2013—Automotive SC-PO1

The interviewee spoke from the position of a manufacturing company located in Australia that was part of an automotive SC-PO1. This company produced engines and was directly affected by imported goods being trapped and damaged in transit over the Pacific Ocean. Consequently, significant shortages in stock occurred, which was sustained for a prolonged period in the manufacturing company, causing the plant to stop operating for 12 hours and curtailing production time for an additional working day. Therefore, the manufacturing company was analysed as a DAO.

The SC manager reported that a delay in one shipment would not cause significant disruption in this SC. However, as the 2013 Pacific Ocean typhoon season included several typhoons in close proximity, it resulted in storms capturing and damaging multiple shipments of the same type of supply on their way to the DAO.

The interviewee explained that his suppliers were not directly affected by the typhoon season, but the cargo was trapped. Shutting down and delayed production induced an indirect effect on wholesalers (see Figure 4-33).

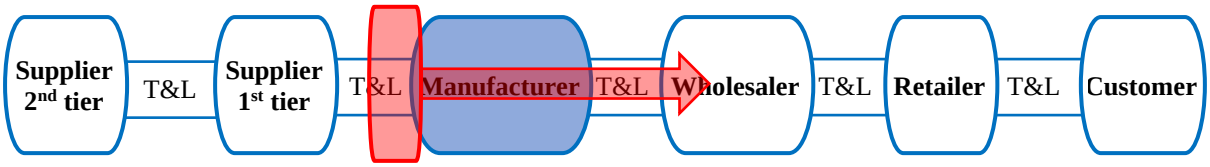


***Figure 4-33**: Graphical representation SC-PO1 and effect of natural disaster on it*

Although the interviewee indicated 12 hours of operations were lost an additional 24 hours were needed to reach full production capacity, he did not provide an exact financial estimation of losses. Since the firm stopped manufacturing but did not completely shut down the facility, they carried on with maintenance and training activities. The interviewee claimed the financial losses were smaller than they would be if the factory shut completely, which he estimates would be above AUD3.5 million.

As part of the *Preparation* stage discussion, the interviewee reported that their SC was often disputed by typhoon seasons in the Pacific zone:

> *There's been a number of extreme weather events. Most of them all centre around hurricanes and monsoon cyclone events which disrupt the shipping lanes.*

Based on this experience, the DAO included Early Anticipation in their planning cycle by ordering extra stock to buffer the effects of natural disasters:

> *We put a transit stock bank into the system. We had obviously excess inventory floating around when the ships came in on time, but that was a small price to pay in comparison with implied risks.*

The interviewee described the *Initial Response* stage in terms of knowing that typhoons might affect supply for a short time before the first typhoon began having a significant impact. Informational Internal SCI was employed as communication upwards in the organisation during this stage. In addition, Informational SCI with their buyer was utilised to gain an appreciation of the buyer's priorities and what needed to be done to address them—'*You have to check with customers and determine what they want to do under the circumstance'*. Operational Internal SCI was described as cooperation between multiple teams within the organisation to find ways to address buyers' needs:

> *So, there's looking at engineering ways of getting around the problem, logistic, legal, and engineering team come together and work together. When you know that you're in trouble you need the whole team to work very cohesively.*

When all stocks were drained, production stopped. During this interruption there was no need for the *Reconstruction* stage as the facilities of the DAO were not affected. However,

some variation of this stage occurred, since employees were organised to perform additional maintenance activities and go through training to prepare for fast recovery when stocks arrived. Internal Informational and Operational SCI were utilised to support these operations.

Immediately after stocks were available, the manufacturer restarted production and quickly reached full operation. The interviewee described how low employee turnover supported Relational Internal SCI in terms of strong relationships and feelings of ownership, which supported Operational Internal SCI through employees' increased effort during the *Reconstruction* and *Recovery* stages when supplies arrived:

> *It was more of a big family so a lot of people just pulling together and doing what they needed to do and what was the right thing to do, without having to be told or pushed.*

Priorities were negotiated with buyers when the DAO started operating again and Operational SCI with buyers involved having them deplete their existing stocks rather than pressuring the DAO to use air freight. Relational SCI with buyers and suppliers was jointly described as a feeling of partnership within industry, and close human relationships between the staff of different companies:

> *I would say that all of our suppliers and all of our customers were all very well integrated into the broader agenda. The automotive business entails understanding that things change all the time and the more accepting you can be of the ambiguity that works around all that change, the better off everyone will be.*

The interviewee described Informational SCI with suppliers in terms of communication about order changes—*So, it wasn't uncommon for us to ask the supplier to work overtime to replace a shipment … to make up for a hole in the pipeline*—which also implies Operational SCI with suppliers. Additionally, the interviewee described Operational SCI with suppliers being supported by Relational SCI with suppliers:

> *I always found that in an autocratic relationship where you just stamp your foot and make unreasonable demands, it might work once but it won't work twice.*

The interviewee added that his company was willing to invest additional resources and risk increased financial losses from natural disasters to preserve good relationships with buyers. Finally, the *Mitigation* stage was described as learning from previous experiences and improving previous response plans:

> *It's the old boy scout thing. You can be better prepared at all times, there's always things that you can do and so that's great. With experience, you tend to recognise patterns and things that happen, have happened previously, that you can learn from.*

4.3.10 Anzac Day hailstorm in Huntingwood (2015)

On Anzac Day (25 April) 2015, a sudden and unpredicted hailstorm affected all of Sydney, with the most severe effect in the Huntingwood area, which hosts national distribution warehouses, factories and other industrial facilities (Lambert, 2015; O'Brien & Shelley, 2015). Initially, the hailstorm severely damaged three factories in Huntingwood, which soon increased to five industrial buildings being damaged as roofs collapsed (Ferguson, Abate, & Turner, 2015) under 1.5 m of hail (O'Brien & Shelley, 2015). Further, one of the buildings had a gas leak, which created an additional danger following the storm (Ferguson et al., 2015; Oxford, 2015).

Main roads in the area were closed and traffic was severely disrupted, with vehicles trapped under bridges or simply destroyed by large hailstones (AAP, 2015b; Ferguson et al., 2015). Over 50,000 properties lost power on the day of the storm, and 4,000 properties remained cut off the following day (O'Brien & Shelley, 2015). Affected industries included retail supermarkets, T&L companies, third-party courier distributors, car part suppliers and real estate businesses (Cummins, 2015a).

Companies directly affected by the Anzac Day hailstorm included Beiersdorf aerosol product storage and distribution centre (about 10,000 m^2); Hitachi national retail distribution centre; Linfox retail storage and distribution centre; Costco national storage and distribution warehouse (30,000 m^2); Hyundai Mobis national retail storage and distribution centre (which reported damage to stock worth AUD2.5 million); and Metcash distribution centre. Multiple other companies in the area had minor damage and flooding, including Arnott's biscuit company storage, which had over 13,000 tins destroyed (Cummins, 2015a).

On 1 May 2015, the ICA declared the Anzac Day hailstorm a catastrophe and by June 2015 they had received 14,239 claims totalling AUD389.9 million (Cummins, 2015b). Some of the companies affected in this disaster are examined as SC-A1 and SC-A2. SC-A1 is examined using secondary data and name of the company was publicly available—Metcash Ltd, a retail wholesaler. The SC-A2 is a healthcare SC examined using direct interview.

The effect of the Anzac Day hailstorm is not presented in the form of the map due to insufficient data available on the affected area.

Anzac Day hailstorm 1—Retail perishable and non-perishable SC-A1

One of the affected companies is Metcash, Australia's leading wholesaler supplying over 10,000 retailers nationally. Although Fire and Rescue NSW estimated less damage on

their facilities than other companies (Lambert, 2015), Metcash estimated material and consequential losses at AUD57 million. They had to close their 82,853 m^2 Huntingwood distribution centre and start utilising warehouses from Victoria and Queensland to supply buyers from NSW following the storm. However, as the distribution centre in Huntingwood needed one year to recover, Metcash opened three new temporary warehouses in NSW to keep customers in that state supported (Cummins, 2015a; Metcash, 2016). Initially, the company opened four distribution centres before November 2015 to support major retailers during the peak season (Watson, 2015), but only three were kept in 2016 (Metcash, 2016). Although company representatives repeatedly stated that they were doing their best to minimise the impact on retailers, some stock supplied by Metcash was not available in supermarkets as an outcome of the hailstorm (Cummins, 2015b).

Secondary sources did not reveal any effect being transferred to manufacturers. The structure of the SC-A1 and effect of the disaster on the SC are presented in Figure 4-34.

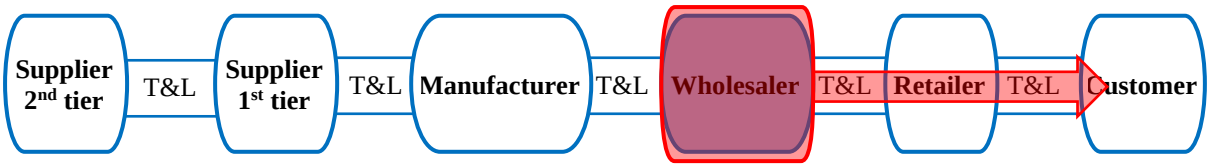


***Figure 4-34**: Graphical representation SC-A1 and effect of natural disaster on it*

An initial half-year report from November 2015 indicated that material damage and consequential losses were expected to be covered by insurance; however, it also acknowledges that operating cash flow was reduced by AUD90 million as a result of the hailstorm damage. The estimated impact of the storm on sales to supermarkets was around 1%, and total wholesales excluding tobacco around 0.4% (Watson, 2015).

The CEO of Metcash at the time, Ian Morrice, was unaware that the hailstorm was approaching and was surprised by the magnitude of its power when it struck—'*We were all surprised by the force of the sudden hailstorm on Saturday'* (as cited in Herrmann, 2015, p. 1). The company suffered significant damage as a consequence of not being prepared on the day:

> *Unfortunately, our distribution centre at Huntingwood has sustained significant damage … Damage is sufficiently serious and the ability to service orders of dry grocery and liquor in the short term has been impacted (Morrice, as cited in Herrmann, 2015, p. 1).*

The unpredicted nature of the hailstorm meant that preparation plans were not activated; consequently, safety and security operations were not put in place within the *Initial Response* stage.

During the second part of the *Initial Response* stage, Metcash conducted a damage evaluation and determined how to proceed (Neems, 2015). Operational Internal SCI supported these operations through team coordination and employees' increased effort during this stage:

> *Teams of Metcash staff worked hard over the weekend to put arrangements in place to minimise the impact on supplied retailers and their customers (Morrice, as cited in Metcash Media Release 27 April, 2015).*

Major buyers were updated about possible delays as estimations were conducted and plans for the recovery developed:

> *We have alerted our retail customers to the issue and explained that whilst the continuity processes are implemented, there may be delays in delivering product, (Morrice, as cited in Associate Analysts, 2015; Neems, 2015, p. 1).*

Metcash started operating in an alternative form of SC two days after the initial impact of the natural disaster. During this time, the *Reconstruction* stage began at the directly affected location and alternative hubs were utilised to support buyers and generate profit for completion of the *Reconstruction* stage at the affected location. This SC-A1 entered the *Recovery* stage before completing the *Reconstruction* stage by opening temporary hubs. Metcash continued information exchanges with public organisations from the time of the initial impact until complete recovery.

Metcash utilised various tactics to achieve recovery. These actions were part of plans developed previously to deal with a crisis that made engaging alternative operations necessary:

> *When our Huntingwood distribution facility was damaged by hail in April 2015, our business continuity planning came to the fore (Morrice, as cited in Metcash, 2016, p. 8; AA, 2015).*

The manager added that these plans proved effective during the *Reconstruction* and *Recovery* stages as a result of joint operations and strong relationships with suppliers and buyers, and the strength of internal relationships (the secondary data did not offer any insights pertinent to the *Mitigation* stage):

> *This is testimony to the strength of our relationships with our suppliers and our customers, and the commitment of our people. I am pleased to note that Huntingwood is now operational again, having been out of action for 12 months. I am humbled by*

> *the support that exists within the Metcash network and proud of our team's commitment to our customers and their businesses. (Morrice, as cited in Metcash, 2016, p. 8).*

Anzac Day hailstorm 2—T&L in Healthcare SC-A2

The SC manager commented on SC-A2 from the perspective of a directly affected T&L company that links a wholesale importer of goods with retailers and other businesses. The storm directly affected the T&L company that operates as part of the healthcare industry, storing and distributing equipment and medicines.

The DAO was located near the Metcash distribution centre. The upstream effect of the hailstorm was imposed on manufacturers overseas and the downstream effect was transferred to buyers, as their goods were inundated, and insurance estimations were needed. This created delay in deliveries to the buyers and their customers (see Figure 4-35).

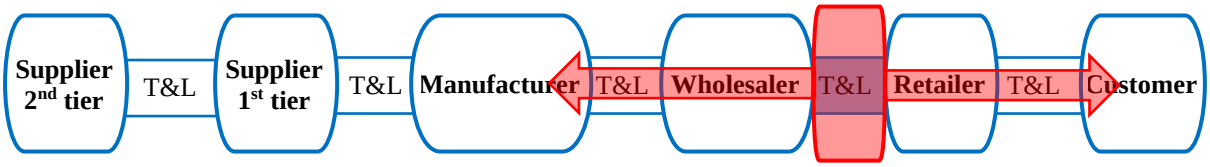


***Figure 4-35**: Graphical representation SC-A2 and effect of natural disaster on it*

During the *Preparation* stage discussion, the interviewee reported that the management collectively acted as an emergency planning team and developed strategies for addressing potential crises. The *Initial Response* stage began one hour before the storm impacted the SC when the BOM began issuing warnings—'*When the hailstorm happened, we were already getting alarms via our phone'.* Due to the lateness of these warnings no safety measures were operationalised; however, when the management team arrived at the location and assessed the situation, they initiated measures to protect both the staff and the security of the product that could be damaged and was critical to hospitals and pharmacies:

> *Managers were able to get to our site to assess safety. When they got at the location and entered inside the property, the first thing was to check on power supply because our site holds the Australia-wide pharmaceutical products.*

When safety was secured and management were assured of a continual power supply, employees gathered at the warehouse and began cleaning the site. The aim was to carefully estimate the damage and establish a strategy that would initiate repairs and restart operations:

> *A lot of us then went to site, so that's afternoon, to assess what was going on. What we did immediately was to get into action cleaning stuff, removing scraps. Then we had to mop up all of the water around all of the flooring areas, and all damage was estimated*

> *within 24 hours. We were able to restart some operations two days after the initial impact.*

Informational Internal SCI utilised during this process entailed communication upwards to ensure power supply continuity, communication downwards from management to employees and distribution of decisions made by emergency team to employees:

> *In the first couple of hours there were some calls being made to make sure we did not lose further power to our building. We contacted our directors and they contacted the CEO. We also contacted all staff to advise do not come into work. We had a general management team come to site and they set up themselves in the board room, so they had a base set up to address everything that was occurring. They were aware, they were involved, and they put plans together.*

Informational SCI with buyers was utilised in this stage to notify them about products that were damaged:

> *At the same time as damage assessment was being conducted there was a communication process to our customers because there would have been insurance requirements that they needed to deal with the effects on their products.*

In addition, Operational SCI with buyers was utilised as joint teams were assembled to assess the damage and work on reconstructing the site. The interviewee emphasised that strong relationships with buyers was based on Informational SCI being established and prompt notification:

> *The relationship with buyers was very strong because we were very quick to communicate what had occurred.*

Communication, cooperation and an even closer relationship with government organisations existed during the *Initial Response* and *Reconstruction* stages. It involved receiving notifications from weather-related services and explaining to public services why a continuous power supply was crucial for the interviewee's SC, thereby ensuring power supply was not interrupted:

> *The police advised there was a chance of a gas leak somewhere. They were going to switch off our generator, which would have been bad for our products. We contacted our directors to contact the CEO, who spoke to the government and persuaded emergency teams not to switch off our generator at the time. With the concern about possibly losing power to the site, I would suggest that, if there was a similar scenario again, we would have contact with the emergency services in a manner where they understand that we have lifesaving products within our warehouse because we need to make sure we're still operating to the point of continuing to supply without any effect to that. So, closer contact with them, maybe a stronger relationship would be even better for us in the future.*

In the discussion about the *Recovery* stage, the interviewee underscored the importance of Informational Internal SCI—'*Our QA department put out a letter to everyone in the company to advise what was going on'.* Communication upwards to the management team was also mentioned when describing the behaviour of all employees working together on the recovery:

> *The general management team, or the main team that was managing the whole situation, they were really the main point of contact for all of us to ensure that we were following the plan. Employees got in and it really helped us to get things going quickly. They just did whatever they need to do, they just did it and worked with us.*

The employees' increased effort was explained as an outcome of Relational SCI within the company in terms of employees' feelings of ownership:

> *I must say our company employees are very positive in their approach to things. They take some ownership of what they look after for our business. They were very willing and happy to work with us to get things back up and running again in a time frame that we could work to as a team.*

Informational SCI with buyers and with buyer's buyers during the *Recovery* stage prioritised communicating progress on the rate of recovery and possible impacts downstream in the SC:

> *Our management communicated to our customers and their customers. There would have been some effect to them, so the communication was about that effect. There was certainly plenty of verbal communication to ensure our customers were kept well-informed of what was happening.*

Relational SCI with buyers and buyers' buyers were described as strong relationships and care for them—'*We have very good employees that are dedicated to looking out for their customers'.*

The *Mitigation* stage was described as a process of improving existing continuity plans with learning gained through this experience:

> *It was a basic business continuity plan back at that time. The learnings we got showed that we really needed to improve that to something that was even better. We have upgraded that basic plans since then, implementing learnings we got from this situation and we made it even stronger.*

4.3.11 Australian flood (2010) after the Millennium drought (2000–2010)

The Millennium drought was the worst in 110 years, before which records were not kept. It was particularly serious due to a prolonged period of very high temperatures and no rain (Kirby, Connor, Bark, Qureshi, & Keyworth, 2012). Rainfall began to be irregular in 1996, and in 2001, El Nino brought drought conditions over almost the entire continent, lasting until 2005. From 2006 to 2007, southeast Australia, especially the Murray-Darling River basin,

experienced the driest conditions ever recorded (BOM, 2001–2010). The following two years (2008 and 2009) also brought prolonged drought across Australia (BOM, 2001–2010).

Due to extended nature of the drought and disagreement over when it began, researchers have been unable to quantify the economic impact, and the cumulative effects make estimations even more complex (Van Dijk et al., 2013).

Major consequences of the drought were felt in rice and cotton production: rice production fell by 99% and cotton by 84%. Cotton producers swapped to winter cereals, but as rice producers could not do this, many shut down (Kirby et al., 2012). Summer-bearing orange producers reduced production by 32% and around 3% of national forestry plantations were lost in southeast Australia (Van Dijk et al., 2013).

The interviewee from the case SC-AM1 described the severity of the effects of the drought:

> *Farmers were committing suicide … It was a horrific event across the whole of New South Wales … the drought broke in 2011 or 12, and there was a massive flood … We lost some vehicles in floodwaters and a few other things … [but] droughts cause us a lot more impact than flooding.*

After the drought, floods occurred in Queensland, NSW, Victoria and South Australia (Murray & Bhutia, 2011). By the beginning of 2011, almost 75% of NSW was evacuated or under flood warnings (Floods in New South Wales, 2019; NSW and Victoria flooding, 2012). Extreme floods were caused by intensifying rain and two cyclones. TC Tasha occurred at the end of December 2010, causing floods of Biblical proportions (Woods, 2011), and TC Yasi occurred at the end of January 2011, bringing floods over NSW (Ferguson & Barry, 2011). The floods caused about AUD300 million damage to agricultural SCs, especially banana and sugarcane crops (Ferguson & Barry, 2011).

One of the most affected agricultural products in these natural disasters was the product of SC-AM1 examined in this study. To represent the effect of drought and flood on agricultural SCs, the author developed the map presented in Figure 4-36 (adapted from BOM, 2012b; Department of Foreign Affairs and Trade, 2012; Van Dijk et al., 2013).

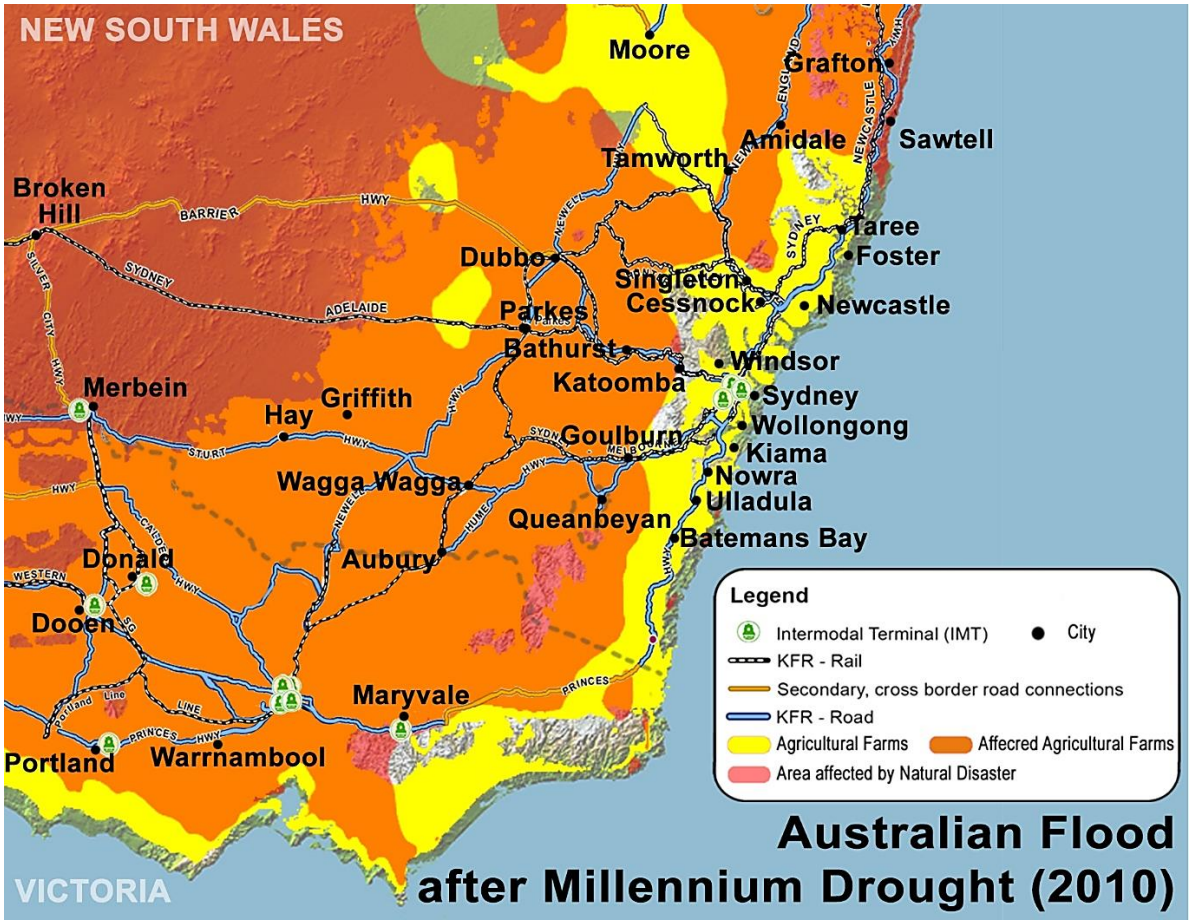


***Figure 4-36**: Influence of Millennium drought and flood on agricultural SCs*

Millennium drought and flood—Agricultural SC-AM1

The SC manager for this agricultural SC-AM1 spoke from the position of a first-tier supplier directly and indirectly affected by the Millennium drought and floods. As the direct effect was significant, the interviewee was analysed as a DAO.

The DAO has its main offices in Sydney, NSW, while their fields affected in the flood are located in central southern NSW. The interview was focused on SCRES process in relation to flood that came after the drought; however, this SCRES building was heavily influenced by consequences of the drought the DAO had suffered for 10 years before the flood occurred. This was particularly important for the DAO because their crops were the ones most affected in the Australian agricultural industry.

As in most agricultural and food SCs, the DAO owns and manages fields that supply manufacturing facilities, which later supply wholesalers and supermarkets with food. While describing the effect of flood, the SC manager focused mostly on the effects experienced by the first-tier supplier, on their fields. The DAO was directly affected by the Millennium drought and before it managed to recover, it was directly affected by flood; yet, the SC manager was

unable to distinguish completely between the impact of the drought and the flood on the SC. However, he was able to describe financial and operational damage from flood observing that it was significantly smaller than damages from the drought. This financial damage was significant. Production was reduced for four weeks compared with production capacity before the flood, crops were lost, deliveries to main buyers overseas were delayed, and two large vehicles were completely damaged in the flood. SC-AM1 was fragile before the flood started. It had changed the way it operated, restructured completely and suffered significant operational and financial losses before the flood even started.

In the flood, the DAO was affected directly and indirectly. The interviewee described the indirect effect of the flood in terms of severed transport infrastructure, declaring this difficulty proved a greater concern than the direct impact on his company:

> *The main significant impact upon us was our logistics transport network, given all the routes were effectively flooded out.*

Downstream, the flood indirectly affected customers in this SC in terms of delayed product delivery—'*Our customers are only affected by our inability to get products to them'*. Figure 4-37 presents structure of the SC-AM1 and the effect of the disaster.

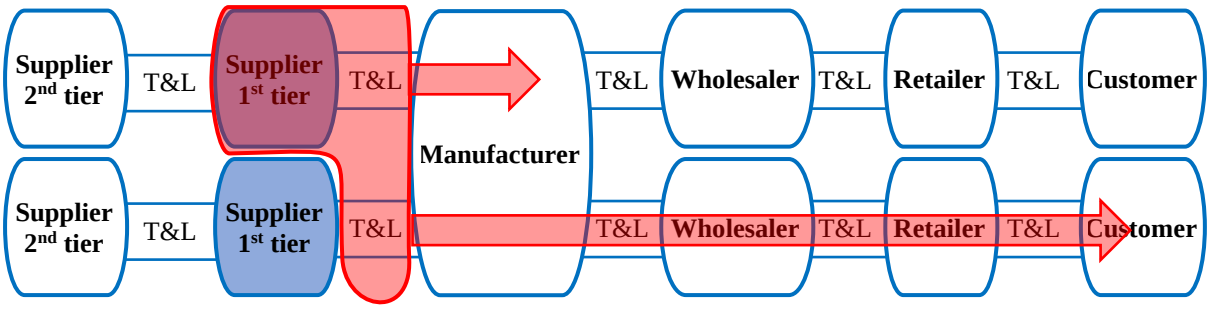


***Figure 4-37**: Graphical representation SC-AM1 and effect of natural disaster on it*

As part of the discussion on the *Preparation* stage and flooding event, the interviewee described having some plans in place for flooding events, but advised that the plans would not have been sufficiently effective because they had not completely recovered from the drought when the flood struck.

The *Initial Response* stage started when the DAO attempted to evaluate the impact and progress of the flood through weather reports, and then harvest as much crop as possible until it was unsafe to drive through the water—'*Get equipment in paddocks and do what we need to*

do from a harvest and a growing perspective'. This operation was not planned Opportunistic Operation and it even caused some damage to vehicles, as it was not organised in a timely manner and the effect was unexpected. After the floodwater was too high to operate, safety and security measures were conducted:

> *So, there was some managing concerns about our operations, facilities, equipment, staff, people, etc. There were some immediate impact with the flood, obviously we needed to secure transport.*

When the flood started retreating, the interviewee began evaluating the damage and designing possible strategies to re-establish normal operations—'*There was a clear issue around putting in place logistics operations both during and after the flood'*. This indicates Internal Informational and Operational SCI were utilised to support the *Reconstruction* stage and undertake site cleaning.

The interviewee described Informational SCI and the importance of trust with buyers during the *Initial Response*, *Reconstruction* and *Recovery* stages:

> *I think, at that point it really is just about keeping your customer base informed. Once they know there's a problem and you've been proactive and you're working with them, they know it's not something you did, they know it's not your fault, they're just looking for you to be honest, open, and communicate what's going on with them.*

The interviewee described utilising publicly available scientific data himself and advised that he contacted governmental organisations only as a last resort to clarify information on possible disaster predictions.

As part of the *Recovery* stage discussion, the interviewee emphasised the importance of Informational and Operational SCI with a buyer because the DAO needed to receive urgent delivery information and prioritise them:

> *We did get some customers who rang up saying they needed some product urgently. We certainly tried to prioritise deliveries to them.*

The interviewee explained that Relational SCI with buyers from Australian customers was strong; they had a robust understanding due to being well-informed about the circumstances by the media. However, overseas customers needed regular updates on flooding and recovery. In this discussion, Informational SCI with buyers assisted Relational SCI with them, and Relational SCI with buyers supported Operational SCI , with efforts invested on both sides to achieve faster recovery of the entire SC:

> *It was a matter of us updating them. When we did this, when we communicated, they understood the situation. They expect to be kept informed, they expect to be told what's happening, and they're happy to work with us once we built this understanding.*

The interviewee expanded on this discussion while adding that information exchange via information technology is important, but it cannot substitute Relational SCI in terms of contact between people and the honesty that takes place between them. He found this crucial for SCRES building:

> *You still can't beat the kind of face-to-face, or the actual person to person communication. That artificial intelligence is good from a data perspective, it gives you better visibility and a longer lead time to react, but despite all of that, it all comes down to ensuring that a person to person level of connection exists and making it certain that you have that communication.*

The interviewee also underscored that all three types of SCI with suppliers were utilised in the *Recovery* stage—'*Most of them work with us. We communicated, agree, and cooperated. We had a mutual understanding'*.

The interviewee did not describe any *Mitigation* stage activities in relation to flood. He continued to compare the flood's effect with the drought effect; therefore, the only lessons learned were related to drought because its effect was significantly larger.

4.3.12 Eyjafjallajökull eruption (2010)

On 14 April 2010, the Eyjafjallajökull volcano erupted in Iceland. While the volcanic eruption was small and did not immediately cause alarm, it quickly became a disruptive event. Unusually, fine particles—like 'grey wheat flour*'* (Davies et al., 2010, p. 606)—were formed by the explosion and launched up to 11km high. Westerly winds distributed the ash over Europe in the following days and caused significant disruption in SCs using air transport (Davies et al., 2010). On 16 April 2010, airspace was completely closed in 11 countries and partially closed in nine EU countries (Volcanic ash: Flight chaos to continue into weekend, 2010). The next day, air traffic in Europe was reduced by 50% and early estimates of losses for the air transport industry alone were several hundred million Euros (Alemanno, 2010).

Around 108,000 flights were cancelled and some airlines were bankrupted (Lund & Benediktsson, 2011). Final lost revenue figures were AUD1.827 billion (RBA, 2019 [exchange rate, 16 April 2010]). As air traffic was banned, road and rail traffic were overbooked, and delays occurred.

On 20 April 2010, three T&L companies—DHL, FedEx and TNT—announced delays in their SCs (Iceland volcano cloud: The economic impact, 2010). British private logistics providers warned it would take over two weeks to restart regular operations, as many carriers had their crafts mispositioned. Perishable SCs carrying vegetables, fruit and cut flowers to Europe were completely severed (Business News: Ash disrupts deliveries to British shops, 2010). Kenya, which accounts for 20% of flower imports to Europe, had to destroy a million roses (Alexander, 2013).

To visually represent the effect of volcanic ash on SCs relying on air transport, such as SC-VE1 examined in this study, the author developed a map presented in Figure 4-38 (adapted from Lund & Benediktsson, 2011), utilising Google maps.

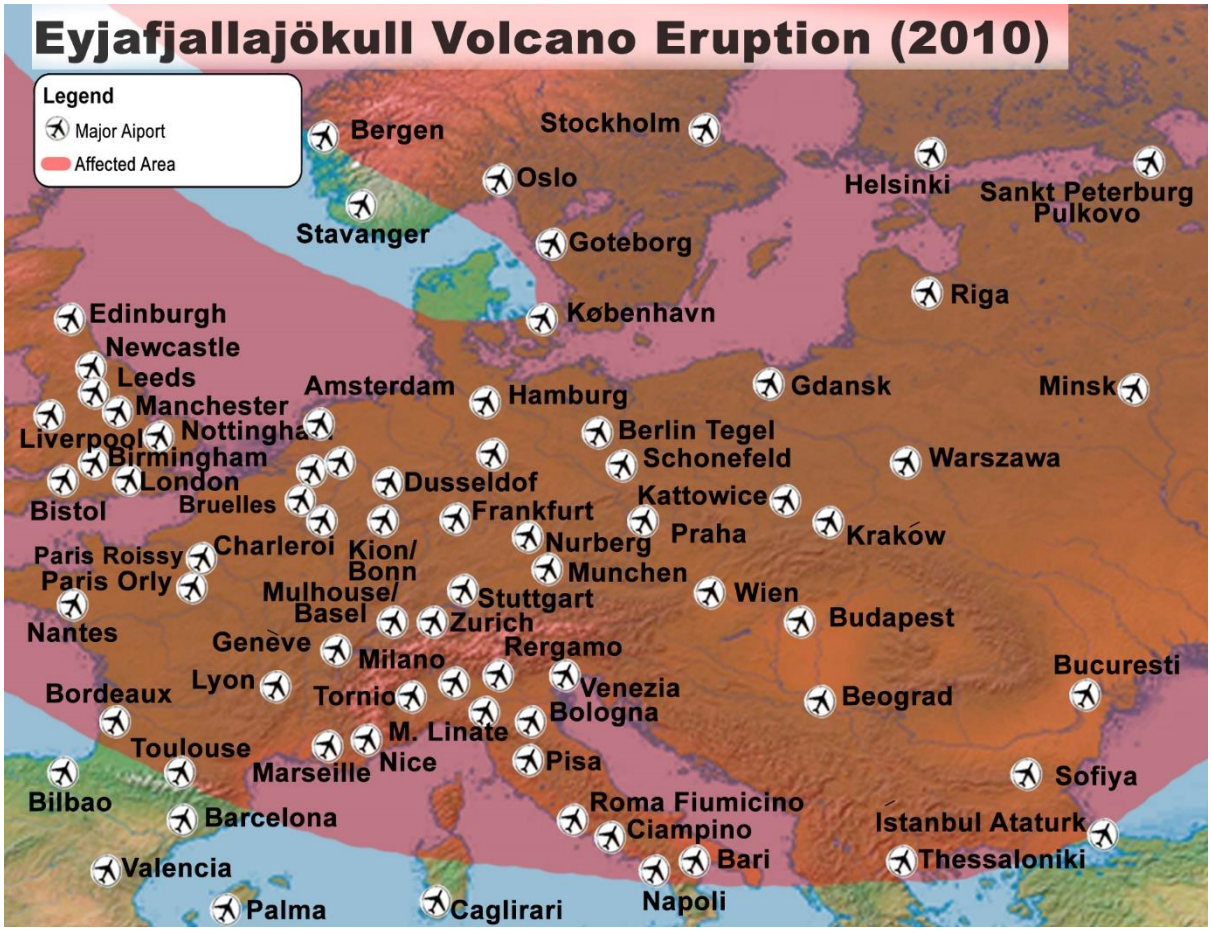


***Figure 4-38**: Influence of volcanic ash from Eyjafjallajökull on SCs relying on air traffic*

Eyjafjallajökull—T&L in perishable SC-VE1

In the perishable retail SC-VE1, the interviewee spoke from the position of a T&L company. This company operated between manufacturers and wholesalers, and between wholesalers and retailers. They ensure the supply of fresh-cut flowers, and exotic fruit and vegetables to European retailers from different manufacturers in other continents. Together

with some other producers of pharmaceutical products, they transport from overseas wholesalers to retailers in Europe. Flights over the country where this company is located were banned by air traffic control from 15 April 2010. The nature of this natural disaster meant that although wholesalers and retailers were directly affected by the ash cloud, they continued to demand their stock got delivered. Only SCs that include products T&L had to transport quickly and keep fresh were affected.

The natural disaster had a direct effect on interviewee's company and the firm was placed in the position of a DAO in the analysis. The effect of the disaster was transferred upstream and downstream in the SC-VE1. To represent the effect on distribution, different cases are distinguished in different schematic representations. The interviewee explained, '*There were flowers, there was food, there were perishables'.*

In the case of manufacturers needing airfreight to Europe, manufacturers were affected via upstream transfer of effect from the directly affected T&L company. Wholesalers were affected downstream, in terms of delayed transport or even damaged or lost products that were supposed to come from wholesalers, which was the case in the transport of fresh roses or exotic fruit and vegetables that needed to be disposed of. This additionally affected retailers that did not receive their fresh roses or fruit, and customers that were unable to buy these products in the flower shops or supermarkets. For example, the wholesaler that needed to airfreight some pharmaceutical products was affected by upstream effects from DAO T&L, and retailers and customers were affected via downstream transfer of effect.

While the DAO T&L does not rely solely on air transport, this division generates significant profit. To capture developed insights on the SC structure, a graphical representation is provided in Figure 4-39.

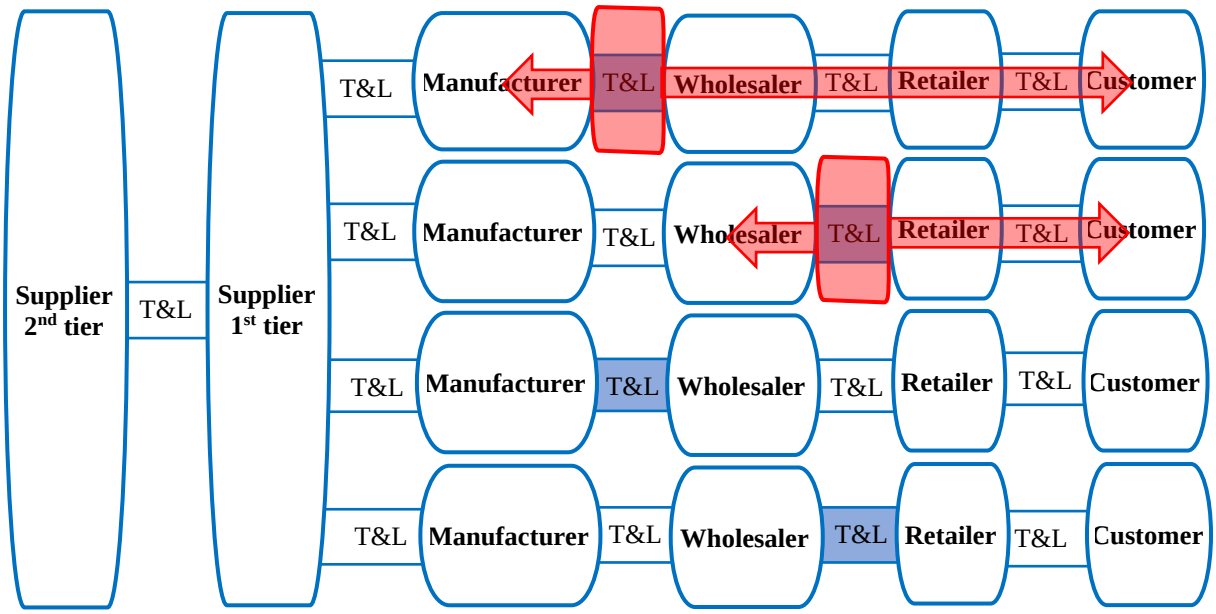


***Figure 4-39**: Graphical representation SC-VE1 and effect of natural disaster on it*

The DAO T&L had to change the way they operated and open a completely new hub in a country in which they had not previously operated. This caused significant losses in terms of investment in the new section of the SC; however, additional losses were experienced due to profit loss before this hub was opened as goods had to be disposed of due to their perishable nature. As the interviewee indicated, '*tonnes of food were lost'*.

The *Preparation* stage discussion included a description of the contingency plans the company had in place for a halt in deliveries and the designated emergency team; however, the firm had not prepared for the specific crisis that befell. When describing the *Initial Response* stage, the interviewee advised that the DAO T&L was unaware of a major disruption until it started happening:

> *What happened was the volcano erupted and it didn't bother anyone because it was Iceland, so no one really cared, sadly. Then, the ash cloud appeared and started moving sideways and then it stopped aerial operations.*

The interviewee explained that the T&L continued utilising road and rail transport as usual. After the management realised on 15 April that air traffic was severed, they tried to communicate with governmental organisations and reach some agreement to allow air traffic; however, this was unsuccessful:

> *And the first reaction was panic, of course. And then they tried going to the safety organisations and they tried to challenge the decision.*

The T&L then evaluated the situation and made decisions based on the availability of good communication and cooperation with the government of the island on which they chose to build a hub:

> *I mean, [island name] is beautiful, I could live there, but no one would make a lot of fuss about it and where they could have some level of influence towards the government.*

During this time, the DAO T&L needed six days to restart airfreight operations in Europe through the newly established hub. The establishment and preparation of the new hub for operations is analysed as part of the *Reconstruction* stage.

Informational and Operational Internal SCI were described in terms of good communication and coordination between managers in making executives decisions and creating an alternative operations plan to prepare this site for operations—'*They started putting the solution together'.* The interviewee added that Operational SCI was very important during the *Reconstruction* stage:

> *Teams joined they came together, reacted fast and adjusted quickly. Very fast coordination demanded here.*

When discussing the *Recovery* stage, the interviewee observed that the alternative hub operated well, but as it was new and far smaller, operations did not reach 100% capacity immediately:

> *We thought that [island name] received 100% of the shipments that [European main hub country] was supposed to receive. The island received the Asian shipments so operation could continue, but it was still disrupted. Operation was disrupted, of course.*

After six weeks of work in the newly established hub, the T&L started moving north as the air ban was withdrawn, and finally reopened the original hub a few weeks later. In total, it took nine weeks to reach the original SC capacity of operations.

Informational and Operational SCI was described in terms of communicating about changes and engaging employees from other offices to be transferred and engaged in operations in the new hub. In addition, Operational Internal SCI was described as coordination between teams, which was highly valuable for the recovery:

> *When that happened and when they put the solution on [island name], they organised a team … They had a person that was heading the ferry operations, a person that was heading the travel operations, a person that was in charge of lobbying government if they had to, a person in charge of actual people, people just normal hands to restaff or restaff load, et cetera. So, it was a very well-coordinated effort and that's why they were successful.*

Relational Internal SCI involved a high level of trust between employees and management and this supported Operational SCI in terms of the integrity of managers, which enabled them to influence employees, increase employee effort and improve coordination:

> *They put the right people on the right roads. People that were knowledgeable, not just in the expertise area, but they had the capacity to actually influence other people.*

Informational SCI with buyers was described as involving frequent communication on recovery development and joint work on prioritisation of goods. This also included Operational SCI with buyers, described as an investment of additional resources when delivery was urgent:

> *There was a lot of back and forth communication, of course, in terms of change documents. Do you really need this to be delivered? Yes. All right, this is what you need to do … They would put additional resources in when customers would demand something or say it is urgent.*

Further, the interviewee described how Informational SCI with buyers supported Relational SCI with buyers in terms of constant communication, ensuring that buyers trusted the T&L was working in their best interest. This process enhanced the number of customers who already trusted the T&L and expressed their sympathy with the firm's difficulties. Notably, that relationship had to be built earlier:

> *Customers were asking a lot of course. Communication was crucial here. They needed to ensure customers that they are doing their best and prove that they are putting the best effort to save money and good you know.*

Cooperation with the government was described as part of the *Recovery* process—'*Management had to liaise with the [island name] government in order to start loading bigger cargo planes to land in the island'*. The interviewee added that close cooperation with government was crucial for recovery, especially in situations where unnecessary legal complications occurred:

> *Actual part of planning the loads in the ferries was new to everyone. No one in [T&L company name] had planned a ferry load before. To planning the loads in the trucks from a completely different location, pretty much without any system support, because … agreeing with governments to clear cargoes that were not consigned or shipped to the country.*

When discussing the *Mitigation* stage, the interviewee observed that the company learned from its experience and decided to keep the alternative hub operating with minimal capacity for use when convenient or when compelled to address a similar disruption. He added that this experience made the DAO T&L create new preparation plans:

> *Be prepared. I reckon it was a biggest take for everyone. It's like, we're not going to get caught like this anymore.*

4.3.13 Tohoku earthquake and tsunami (2011)

On 11 March 2011, the strongest earthquake ever recorded in Japan struck the Tohoku region. The disaster started as an earthquake under the ocean and continued as several large tsunami waves (Micalizio, 2014), triggering a nuclear accident and meltdown of three nuclear reactors at Fukushima Daiichi (Micalizio, 2014; Rafferty & Kenneth, 2018). At 2:46 pm local time, the earthquake shook skyscrapers and broke highways in half; then the tsunami came (Fackler, 2011). Warnings had been issued that the wave would be 6 m tall. In the actual event, it was 20 m and a large area was washed away, including complete infrastructure (Suzuki, 2012).

The tsunami inundated more than 400 km^2 (Mori et al., 2012). The number of lives lost is estimated to be almost 20,000 (Dunbar et al., 2011), with damage to 128,530 houses, 230,332 buildings and 78 bridges (Mori et al., 2012). International reports by the United Nations indicate that the Tohoku earthquake and tsunami caused damages over AUD282.5 billion (RBA, 2019 [exchange rate, date of source publication]), making it the costliest natural disaster ever recorded (Wallemacq & House, 2018). The damage disabled even undamaged businesses and halted factories' ability to operate, as the main source of power—the nuclear power plant—ceased operating (Rafferty & Kenneth, 2018). Mobile telecommunications infrastructure was damaged and communication disabled (Fackler, 2011).

The impact of the Tohoku earthquake and tsunami was the most devasting the automotive industry has ever experienced (Carty & Kurtenbach, 2011; CRS, 2011). The industry most affected was the one producing high technology parts and semiconductors for car manufacturers. These businesses did not restart partial operations until August 2011, and it took until 2012 to reach the operation capacity sustained before the disaster (Rafferty & Kenneth, 2018). The SCs of cars assembled in the US were severely disrupted, with the most damage felt by SCs for Japanese cars such as Toyota and Honda. Toyota's profits were reduced by over 75% as major suppliers were completely destroyed (Associated Press, 2011). Competitors GM and Ford gained a larger market share (Edgerton, 2012), but even Ford and Chrysler suspended sales of cars in certain colours as the pigments were supplied by Japan (Tajitsu, 2016). Business analysists have predicted that Toyota will never be able to regain its global market share to pre-disaster levels (Edgerton, 2012).

To present the effect of the Tohoku earthquake and tsunami on automotive SCs, such as SC-ET1 examined in this study, the map presented in Figure 4-40 was developed by the author (adapted from IVMH, 2016; JMA, 2011; Roser, 2018). The map captures the effect on automotive industry suppliers in Japan, and only cities that host their facilities are presented, together with the infrastructure they utilise when operating within automotive SCs.

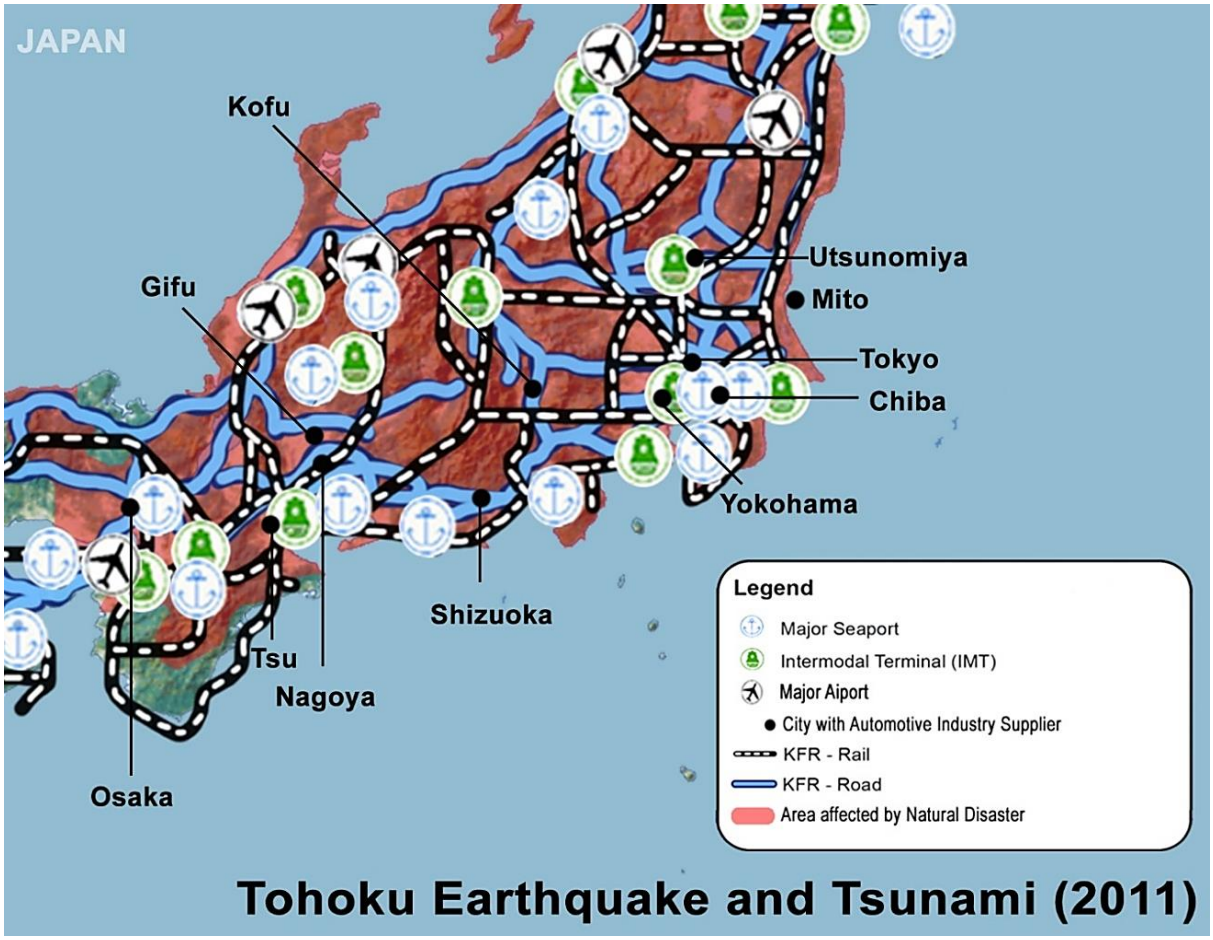


***Figure 4-40**: Influence of Tohoku earthquake and tsunami on supplier SCs with suppliers from Japan*

Tohoku Earthquake—Automotive SC-ET1

The SC-ET1 is an automotive SC servicing a manufacturer located in Australia that imports parts from Japan. In terms of the disaster's effect on the SC, the interviewee spoke from the position of the DAO's buyer, and his company never stopped operating. They found an alternative temporary supplier that supplied them until the DAO fully recovered and started operating per schedule. The DAO (the overseas supplier of the interviewee's company) was affected by damaging winds and floods. Their facilities were inundated and the entire area was evacuated.

The SC manager from the DAO's buyer company was not able to witness any communication or integration taking place during SCRES stages between the DAO and companies other than his own. However, the interviewee explained that his first-tier and second-tier suppliers were affected by the natural disaster. In addition, the SC manager interviewee was able to describe the impact the natural disaster had on his company as a purchaser of the DAO's product and on the DAO. Transfers of the effect that existed in this case SC are presented in Figure 4-41.

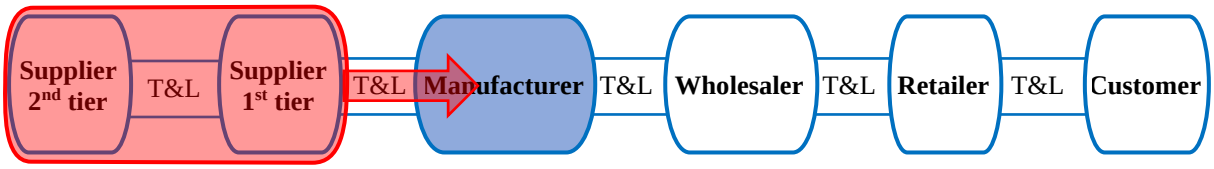


***Figure 4-41**: Graphical representation SC-ET1 and effect of natural disaster on it*

As part of the *Preparation* stage discussion, the interviewee reported that his SC had been affected by natural disasters a couple of times before the Tohoku earthquake and tsunami occurred, and in all cases had no Early Anticipation as these events were not seasonal. The manufacturing company kept two weeks' redundancy at the location, but no extra stock was kept to allow for a natural disaster buffering and there was no emergency team. Therefore, explanation of preparation plans was mostly discussed in relation to safety stocks:

> *So, definitely at least two weeks to one month safety stock should be kept in storage or available at least. And the important thing is to find a clear proportion between how much stock you keep, and how much, or how long is the lead time.*

The interviewee reported that the *Initial Response* stage centred on safety measures at the DAO's location and added that the firm communicated with governmental organisations to coordinate returning to the site—'*They had to learn from with authorities when they could return'*. The *Initial Response* at the Australian location was immediately supported by Informational Internal SCI, in terms of communication upwards—'*Okay, the first reaction was escalating the matter to the senior management and informing them'.* Since there was no need to conduct safety measures, the interviewee reported that his company immediately started damage control and evaluation of possible consequences—'*Estimate ... number one, estimate the amount of stock left on our side, on their side, or in transit'*—then control was established by sourcing alternative supplies in case of stock depletion:

> *Number two, after that, is checking to resource the parts just in case the extreme weather conditions persist … So, we need to find another source, either from local suppliers, or if not possible, from other overseas branches or suppliers.*

The interviewee also described Informational and Operational Internal SCI in his company and observed that this engaged communication and cooperation between company sectors, including the purchasing, business, legal and quality departments:

> *At this point of time the purchasing department and business department was very active identifying another supplier of the needed parts.*

The interviewee explained that this practice was continued until the original supplier recovered:

> *So, yes. We will source a new supplier and on a temporary basis, we give our original supplier enough time*.

The interviewee described Informational SCI between the DAO and buyer, from the buyer's perspective, in terms of communication on recovery time estimation and damage estimation during the *Reconstruction* stage:

> *We were in close contact with them to inspect and supervise what is happening on their side and to make sure then they finish basically renewal and go back into the line.*

He added in relation to the importance of Internal Informational and Operational SCI in the DAO that '*they had to communicate, to coordinate progress, to make sure that renewal is going smoothly and to get started asap'*.

When discussing Relational SCI between the DAO and the buyer, a lack of trust in some instances was reported, whereby the SC manager from the DAO's buyer expressed major doubts over the truthfulness of reconstruction progress updates:

> *If possible, send supervisors from the company to check the situation of the supplier over there. How they are doing. Are they actually following the plan that they are updating every week, or not?*

The interviewee described his concerns over Informational and Operational SCI inside the DAO not being appropriately utilised to support the *Reconstruction* stage. Further, he explained there was no support expected other than assuring the DAO that they, as buyers, would return to regular cooperation after they restarted operations. Therefore, no Operational SCI with buyers was detected:

> *The only thing they wanted from us, just to make sure that we honour the contract and continue business with them after they reopen. And we did.*

During the *Recovery* stage, the interviewee described Informational and Operational SCI with the buyer:

> *Upon announcement of their readiness we asked them to continue production and based on their schedule that normally exchange between us … We coordinated that jointly, very fast*

No *Mitigation* stage was mentioned in the discussion of full SCRES building process.

4.4 Chapter Summary

This chapter has presented research findings of the within-case analysis. Each natural disaster was presented and the SCs affected by that disaster were described in terms of the effect natural disaster had on them, SCRES building, and SCI employed to support the SCRES building process. The research findings of the cross-case analysis are presented in Chapter 5.

CHAPTER 5: FINDINGS OF CROSS-CASE ANALYSIS

5.1 Introduction

This chapter presents findings of the cross-case analysis undertaken. The aim of cross-case analysis is to analyse all data collected in relation to the research questions. Section 5.2 addresses RQ 1 and elaborates on modifications to the existing SCRES model with the addition of one stage and two operations. It provides an overview of cross-case analysis and descriptions of adaptations generated from data. Section 5.3 responds to RQ 2 and provides a comprehensive overview of all cases relying on interviewees' descriptions of goals of SCRES building. These goals are used to identify performance indicators of successful SCRES building, so SCRES building can be measured.

Section 5.4 addresses RQ 3 and discusses how SCI varied in time in relation to the effects of natural disasters, to support SCRES. This section is divided into three parts. The first comments on variations in SCI scope relating to natural disaster effects, as described in the previous chapters, relying on Frohlich and Westbrook (2001). The second describes SCI orientation variation utilising Flynn et al.'s (2010) structure. It examines the role of SCI with suppliers, with buyers, with T&L providers and internal SCI in SCRES building. The last section addresses the variation and role of SCI with government and community. A chapter summary is presented in Section 5.5.

5.2 SCRES Building Model

This section addresses the first research question (RQ 1):

RQ1: How SCRES building practices compare with existing SCRES building model from the literature?

As an outcome of the first data collection and analysis phase (the first 10 interviews conducted), the initially applied SCRES building model was adapted based on interviewees' insights. The adapted version presented in Table 5-1 was then applied in the analysis of the entire data sample, as shown in Figure 5-1.

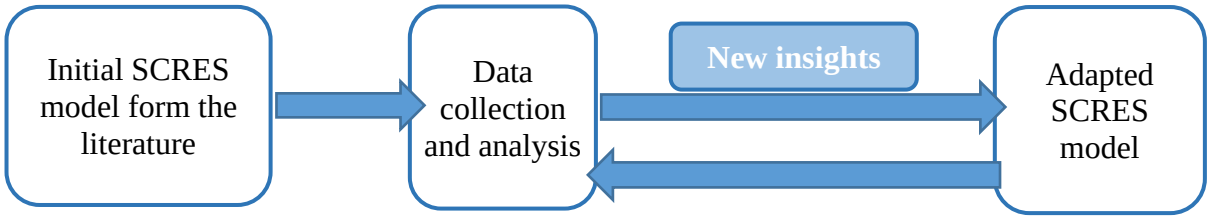


***Figure 5-1**: The process of SCRES adaptation of the SCRES model from the literature*

***Table 5-1**: Adapted SCRES building model in table form*

SCRES building stages	Operations of SCRES building stages
1. Preparation	☑Emergency team ☑ Preparation plan/existing stocks ☐ Early Anticipation
2. Initial Response	☐ Opportunistic Operations ☑ Safety concerns and evacuation of people and property ☑ Implement response plan in terms of evaluations of losses, direction and control
3. Reconstruction	☐ Cleaning, repairing and rebuilding—preparing entire site or part of it so operations, in any capacity, can be restarted
4. Recovery	☑ ~~Implementation of Recovery Plan in terms of Repair and rebuild~~ ☑ Resume/keep operations ☑ Full operations capacity reached
5. Mitigation	☑ Identify and implement improvements in preparation and other plans and procedures

In Table 5-1 that is confirmed to be appropriate as suggested in chapter 3 of this thesis where it was presented as Table 3-3. SCRES stages and operations adopted from the literature are presented in black font, while the new adapted stages/operations are presented in red. The crossed-out text in the fourth stage relating to repairs and rebuilding activities is separated out to a different stage of SCRES building model, the *Reconstruction* stage.

The stages of SCRES building performed by each SC in response to natural disasters' effects are presented in Table 5-2.

***Table 5-2**: SCRES stages detected in different SCs*

Supply chain name	SCRES building stages				
	Stage 1 Preparation	Stage 2 Initial Response	Stage 3 Reconstruction	Stage 4 Recovery	Stage 5 Mitigation
Q1	✓	✓	✓	✓	✓
Q2	✓	✓		✓	✓
T1	✓	✓	✓	✓	✓
T2	✓	✓	✓	✓	✓
T3	✓	✓	✓	✓	
T4		✓		not completed	
HS1	✓	✓		✓	✓
L1	✓	✓	✓	✓	✓
M1	✓	✓	✓	✓	✓
M2	✓	✓	✓	✓	✓
M3	✓	✓	✓	✓	✓
M4	✓	✓	✓	✓	✓
W1	✓	✓		✓	✓
D1	✓	✓	✓	✓	✓
D2	✓	✓	✓	✓	✓
TS1	✓	✓	✓	✓	✓
PO1	✓	✓	✓	✓	✓
A1	✓	✓	✓	✓	
A2	✓	✓	✓	✓	✓
AM1	✓	✓	✓	✓	
VE1	✓	✓	✓	✓	✓
ET1	✓	✓	✓	✓	

Note: ✓ = stage conducted

Data analysis revealed Early Anticipation as a key operation previously unidentified in the *Preparation* stage. Early Anticipation was described as stock held only for the purpose of stopping the effects of a natural disaster transferring further along the SC. SC managers who experienced seasonal events such as typhoons, cyclones or hurricanes, expected these disasters to occur every year. Therefore, even before a natural disaster was predicted by any weather agency, interviewees described increasing their stocks to reduce the impact on their company and stop transferring the natural disaster's impact downstream in the SC.

Another adaptation to the original SCRES model was required because Opportunistic Operations were revealed as the first operation in the *Initial Response* stage. This occurred when a natural disaster's predictability was coded for three or more days before directly impacting the case SCs. SC managers described increasing production and/or shipping capacity as much as possible after a natural disaster threat was known. These operations would be ongoing until one day before the expected direct impact of the disaster. SC managers explained

that this was also conducted under the condition that the company has buyers that are not expected to be affected.

***Table 5-3**: Additional operations in SCRES building and enabling contingencies*

Natural disaster name	Supply chain name	Contingencies examined in relation to additional operations					Additional operations	
		Inbound cargo trapped as the main effect on the SC	Seasonal natural disaster	3+ days warning	Less than 3 days	Not all buyers directly affected	Early Anticipation	Opportunistic Operations
QLD floods	Q1		✓		✓	✓		
	Q2			✓				✓
TC Tasha	T1			✓		✓		✓
	T2		✓		✓	✓		
	T3			✓		✓		✓
	T4				✓			
Hurricane Sandy	HS1	✓	✓	✓		✓	✓	
TC Lua	L1		✓	✓		✓	✓	✓
TC Marcia	M1				✓	✓		
	M2		✓	✓		✓	✓	✓
	M3			✓		✓	✓	✓
	M4				✓	✓		
WA floods	W1	✓	✓		✓	✓		
TC Debbie	D1		✓	✓		✓		✓
	D2				✓	✓		
Typhoon Soudelor	TS1		✓		✓	✓	✓	
Pacific Ocean typhoon season	PO1	✓	✓		✓	✓	✓	
Anzac Day hailstorm	A1				✓	✓		
	A2					✓		
Australian flood after Millennium drought	AM1				✓	✓		
Volcanic Eyjafjallajökull eruption	VE1				✓	✓		
Earthquake Tohoku	ET1				✓			

Note: ✓ = early anticipation and related pre-conditions, ✓ = opportunistic operations and related, enabling pre-conditions.

Table 5-3 captures the natural disaster related contingencies that dictated the additional operations of Early Anticipation and Opportunistic Operations. It also identifies the SCs in which these operations were conducted.

The SCRES model was also adapted by introducing a new stage—*Reconstruction* — that was part of the *Recovery* stage in the initial four-stage model. Interviewees sharply distinguished these actions in their discussion and emphasised that the *Recovery* stage only begins when operations restart, in any capacity, as enabled by the reconstruction. These stages are also distinguished in secondary data too: 'On 28th April *Daily Telegraph* reports on companies in Huntingwood working on cleaning the location and some of them started rebuilding' (Advocate, 2015). In addition to different operations in these two stages, different SCI practices were also utilised to support their successful completion. Moreover, distinguishing *Reconstruction* and *Recovery* stages enabled identification of two out of three main goals of SCRES building: fast restart of operations in any capacity and reaching full capacity of operations.

5.3 SCRES Building—Performance Indicators

This section presents findings in relation to the second research question (RQ2):

RQ2: What are the performance indicators of successful SCRES building process that should be included in the measurement of SCRES?

Data analysis reveals three main goals of SCRES building: (i) fast restart of any operation at all, (ii) quickly reaching full recovery, and (iii) minimising financial losses. These three goals dictate how SC managers evaluate SCRES; therefore, they represent performance indicators of successful SCRES building. Consequently, the present study suggests using the following three indicators to measure SCRES in relation to natural disasters:

(i) time needed to restart operations in any capacity

(ii) time needed to reach full recovery in terms of production and service capacity at the same level as before the disaster effect

(iii) financial losses caused by natural disaster.

Moreover, SC managers described prioritising goals differently, which means focusing on one indicator at the time. The goals were prioritised in the same order they are presented above.

When these SCRES performance indicators are examined against the effect of the natural disaster on the specific organisation in the SC (see Table 5-4), it is found that only the DAO used all three indicators to evaluate SCRES. Indirectly affected organisations did not have their operations interrupted, so they had no need to measure the time needed to restart operations; however, they were only able to reach full recovery when the DAO fully recovered. Further, two DAOs (from SC-HS1 and SC-W1) that were directly affected by their cargo being trapped, still managed to continue operations; therefore, they evaluated their SCRES in the same manner as indirectly affected organisations.

Table 5-4: *SCRES building performance evaluations depending on natural disaster effect*

Supply chain name	Effect on the organisation		SCRES building performance evaluation		
	Direct	Indirect	Fast restart of any operation	Fast full recovery	Financial losses minimisation
Q1	✓		✓	✓	✓
Q2		✓		✓	✓
T1	✓		✓	✓	✓
T2		✓		✓	✓
	✓		✓	✓	✓
T3		✓		✓	✓
	✓		✓	✓	✓
T4	✓	✓	✓	✓	✓
HS1	✓(goods)			✓	✓
L1	✓		✓	✓	✓
M1	✓	✓	✓	✓	✓
M2	✓		✓	✓	✓
M3	✓	✓	✓	✓	✓
M4	✓		✓	✓	✓
W1	✓(goods)	✓		✓	✓
D1	✓		✓	✓	✓
D2	✓		✓	✓	✓
TS1		✓		✓	✓
	✓		✓	✓	✓
PO1	✓		✓	✓	✓
A1	✓		✓	✓	✓
A2	✓		✓	✓	✓
AM1	✓	✓	✓	✓	✓
VE1	✓		✓	✓	✓
ET1		✓		✓	✓
	✓		✓	✓	✓

Note: ✓ = effect present on the SC or indicator used to evaluate performance, ✓ (goods) = effect present on the goods under ownership of interviewee.

The goals of SCRES building also depend on the SCRES building stage (see Table 5-5). During the *Preparation* stage, SC managers are focused on preparing the SC to address all SCRES building goals in future disasters. When natural disaster threatens the SC, managers focus on minimising the impact on people and finances while conducting preparation plans. Further, Opportunistic Operations that occur during this stage also have a goal to minimise financial impact by generating additional revenue. The *Reconstruction* stage is conducted to minimise the time needed to restart operations, and the *Recovery* stage is conducted to minimise the time needed to reach full operations (at the level prior to the natural disaster). Evaluation of operations against performance indicators in all stages takes place in the *Mitigation* stage.

Practitioners' use of these indicators to evaluate SCRES clearly demonstrates that SCRES measurements cannot be established on the SC's potential to be resilient, such as flexibility, agility or redundancy. In the natural disasters' contingency, measurement of SCRES should be related to measuring how successful the SC was in reaching SCRES building goals.

***Table 5-5**: SCRES building goals mapped per SCRES building stage*

SCRES building stages	Goal
1. Preparation	Maximise potential to reach goals of following four stages
2. Initial Response	Minimise losses in terms of lives and finances
3. Reconstruction	Restart operations in any capacity as soon as possible
4. Recovery	Reach full capacity of operations as soon as possible
5. Mitigation	Minimise financial losses

Secondary data analysis also utilised all three indicators to evaluate SCRES. When reporting, the media emphasise the financial cost of the disaster and clearly distinguish between the time needed to restart operations and to reach full operational capacity (Walsh, 2017).

In addition to identifying and prioritising these indicators, the study found variations in the managers' methods of evaluating financial impact. Some simply stated they were unsure how to calculate the financial impact of the natural disaster, so incorporated reductions in the annual budget before the season of the natural disaster. Other SC managers only accounted for lost opportunity, logistic costs, tangible damage or paid workforce. SC managers also described waiving losses related to the paid workforce by engaging employees in auxiliary activities such as cleaning and maintenance. Secondary data supported such inconsistencies in reporting financial damages from the disaster.

5.4 SCI Utilised to Support SCRES

This section addresses the third research question (RQ3):

RQ3: How is SCI utilised to support successful SCRES building?

The study examines adjustments made in SCI in relation to the natural disaster's effect on the SC. The effect of a natural disaster on a SC dictates which stage of SCRES building that SC is currently conducting. This section first considers the scope of SCI, then discusses the orientation and type of SCI. Internal SCI, SCI with suppliers, T&L service providers and buyers of DAO are examined, followed by consideration of SCI with government and community.

5.4.1 SCI scope in SCRES building

Frohlich and Westbrook (2001) introduced 'the arcs of integration' as a concept that describes SCI in terms of its scope in the SC. The authors explain that how far integrative practices reach along one SC can dictate the outcome of the joint effort (see Section 2.5.2.1). The present study builds on this concept due to the transferred effect of natural disasters, and examines how far along the affected SC SCI was altered to support SCRES building. The DAO is the focus of analysis of the scope, as presented in Figure 5-2.

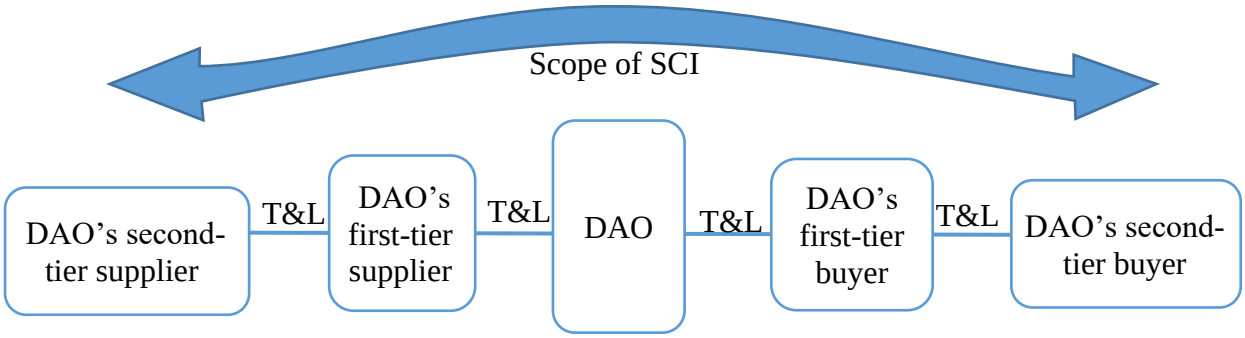


***Figure 5-2**: The scope of SCI in SC in relation to natural disaster effect*

Table 5-6 highlights the scope of SCI in the examined SCs in relation to the natural disaster. In some cases, adjustments were made in SCI during particular SCRES building stages for use in the later SCRES building stages. These adjustments are highlighted in green colour in Table 5-6. Adjustments for use in the same stage are coloured dark grey. Integration across the affected SC starts being adjusted from within the DAO, and this trend continues both downstream and upstream in the SC. SCI adjustments to support SCRES reach further upstream than downstream during the *Initial Response* and *Reconstruction* stages, and further downstream than upstream during the *Recovery* stage. In the *Mitigation* stage, the scope of SCI adjustments reduces.

Table 5-6: *SCI scope in the affected SCs during different SCRES building stages*

SCRES stage	SCI type	SCI orientation							
		↔ Between DAO's supplier and their T&L	↔ Between supplier and DAO	↔ Between T&L and DAO	DAO (internal)	↔ Between buyer and DAO	↔ Between buyer's buyer and DAO	↔ Between government and DAO	↔ Between community and DAO
1. Preparation	Info								
	Oper								
	Rel								
2. Initial response	Info								
	Oper								
	Rel								
3. Reconstruction	Info								
	Oper								
	Rel								
4. Recovery	Info								
	Oper								
	Rel								
5. Mitigation	Info								
	Oper								
	Rel								

Note: Green = SCI built in one stage for later use, grey = SCI utilised in the SCRES building stage.

The scope direction during the *Initial Response* and *Reconstruction* stages is explained by additional Opportunistic Operations that take place during the *Initial Response* stage. This requires interaction with suppliers because they are able to support additional production or shipment.

During the *Recovery* stage, both first-tier and second-tier buyers are much more involved with the DAO to build SCRES by reconnecting and restarting product and service delivery.

During the *Initial Response*, *Reconstruction*, *Recovery* and *Mitigation* stages, SCI with the government also becomes important for SCRES building. The community is only included when the natural disaster is certain, during the *Initial Response*, *Reconstruction* and *Recovery* stages. The explanation of this integrative practice is addressed separately in Section SCI with Government and Community in SCRES building

5.4.2 SCI orientation and type in SCRES

The variations of orientation and type of SCI were jointly presented with SCI scope in Table 5-6; however, additional insights were needed in specific SCs to improve understanding of how SCI was utilised to support SCRES building. SCI variations in each SC examined and the direct statements describing these variations are provided in Appendix C.

Analysis shows that SC managers mostly focused on internal informational and operational SCI utilisation during the *Preparation* stage, when preparation plans are crafted and rehearsed. The scope of SCI used to support the *Initial Response* stage is wider. Internal SCI becomes very important, especially in terms of informational SCI, since communication and decision-making about possible next steps take place within the company. In addition, some SC managers include T&L suppliers and goods suppliers to perform Opportunistic Operations, and some rely on communication with buyers to ensure buyers are aware of possible disturbance or to negotiate with buyers if they are able to receive extensive stock as an outcome of the Opportunistic Operations.

During the *Reconstruction* stage, SCI practices used for SCRES building reach further upstream in the SC. Managers start relying on SCI with T&L service providers and DAOs start intensive communication with indirectly affected parts of SC—especially suppliers—to buffer the effect of natural disaster through the entire SC. In this same stage, the DAO is focused on fast preparation of the site to restart operations, and mainly relies on internal operational SCI. At this stage, internal coordination is crucial.

During the *Recovery* stage, as soon as the DAO restarts operations, SCI with the buyer becomes increasingly important to reduce the impact of the disaster further downstream in the SC. In some cases, communication with buyers is required to keep buyers' confidence and redirect customers to stores that are fully recovered. During this stage, internal SCI remains very important, as interviewees described trying to get the entire SC rebalanced, which requires frequent and accurate communication between different functions in the company. SCI with suppliers was utilised to get extra supplies and adjust existing orders to make up for lost production days during the *Reconstruction* stage. Then, SCI with T&L service providers was utilised to support excessive shipments to buyers immediately once goods are produced.

The *Mitigation* stage is supported by internal informational and operational SCI through communication between company executives to evaluate the SCRES, share knowledge and improve plans with the learning from this experience. Some companies included buyers in the evaluation of possible improvements in the *Preparation* stage.

Further, examples of poor relationships hindering the SCRES building progress and negatively influencing SCRES performance goals were described in the case of SCI with T&L service providers and buyers. For example, in SCs T2 and M2, T&L service providers did not consider SCRES building as a process that requires a joint effort of the entire SC, but they saw an opportunity to gain more profit and increase the prices of regular transport due to the increased demand. In the case of SC-TS1, the buyer reported being unsupportive towards the DAO's recovery, and in SC-M4, the interviewee described tangible damage caused by poor internal informational and operational SCI in response to the natural disaster.

Moreover, analysis shows that SCI and relationships built before the effects of a natural disaster can be utilised to support SCRES building in other stages, such as the *Initial Response*, *Reconstruction* and *Recovery* stages. For example, SC-T1 built internal relationships, SC-HS1 built a relationship with the buyer, and SCs D1 and L1 built strong relationships independent of orientation of SCI for this purpose.

5.4.3 SCI with Government and Community in SCRES building

SCI with the government was described as being important to build during the *Preparation* stage and utilise during the other four stages of SCRES building. Interviewees described communication with the government in predicting seasonal natural disasters. Based on this early prediction, some SC managers conducted a risk assessment for the season and adjusted financial plans for the following year, capturing potential financial losses as part of

natural disaster's effect. The government had a crucial role in information exchange during the *Initial Response* stage, when information was provided by governmental weather forecast agencies. Based on this information, SC managers made decisions regarding Opportunistic Operations—especially delivery—as public organisations were described as the most informed on infrastructure recovery. Constant communication with government was described from the start of the natural disaster's effect to restarting operations. Companies that suffered substantial damage and conducted evacuations continued communication with the authorities to evaluate a safe return to the site and begin the *Reconstruction* stage. SC managers from companies that did not suffer substantial damage continued communication with government to learn when the effects of the natural disaster would withdraw so they could restart operations.

Further, interviewees described cooperation with governmental agencies with the goal to address safety concerns for employees and the community during the *Initial Response* and *Reconstruction* stages. An important example of cooperation with the government occurred in Europe during the volcanic ash dispersion from Iceland. SC VE1 described cooperation with government during the *Reconstruction* stage to establish a new hub for all operations that were hindered by the aerospace ban in Europe. The opening of a new hub proved to be very efficient—it was completed in six days and significantly supported the overall SCRES building performance of the SC-VE1.

During the *Recovery* stage, SC managers described joint efforts on the recovery of infrastructure with government support. However, interviewees also described being unsatisfied with interaction with the government, which highlighted the lack of SCI between the DAOs and the government hindering SCRES building, especially in SCs M4 and L1. Contrastingly, governmental reports (DILGP, 2015) and media releases (Probert, 2017) expressly called for industry to cooperate during all stages of SCRES building. This indicates that the intent of the government to cooperate with commercial organisation on building joint resilience is not well communicated on all levels of the governmental organisations.

SCI with community was described as part of the *Initial Response*, *Reconstruction* and *Recovery* stages, mainly in terms of care for the community. The retail SCs showed the greatest interest in interaction with the community, as it is their direct customer source. This was the case in SCs Q2 and M4 that interact with direct customers on a daily basis, and SC M2 that represents wholesalers under the same ownership as retail stores. In addition, care for the community was expressed in the case of SC-M4, which has the majority of employees coming from the local community. This was also the case for SC-A2, which handles lifesaving and

medical products, and SCs T2 and Q2, which handle necessary products to support community recovery, such as food, water and materials to protect household items.

5.5 Chapter Summary

This chapter has presented findings of the cross-case analysis in relation to the three research questions, with examples from within-case analysis attached to the discussion. The key findings were discussed in relation to SCRES building model expansion, then SCRES performance indicators were reviewed and the SCI practices utilised to support SCRES considered.

Chapter 6 will discuss study findings in relation to relevant literature and present theoretical and practical contributions made by this research, while building on the findings presented in Chapters 4 and 5.

CHAPTER 6: DISCUSSION AND IMPLICATIONS OF RESEARCH FINDINGS

6.1 Introduction

The previous two chapters of this thesis presented the findings to meet the three study objectives:

Objective 1: determine how SCRES building works in practice and expand on the existing SCRES models

Objective 2: identify and describe performance indicators of successful SCRES building as a process and provide guidance for the development of a single, unique SCRES measure

Objective 3: clarify how SCI is utilised to support successful SCRES building and create a model that captures SCRES building, measurements insights and SCI that supports SCRES for future research.

These objectives were addressed in the present study by addressing the following RQs:

RQ1: How do SCRES building practices compare with a SCRES building model extant in the literature?

RQ2: What are the performance indicators of successful SCRES building process that should be included in the measurement of SCRES?

RQ3: How is SCI utilised to support successful SCRES building?

This chapter discusses the key findings from the within-case analysis and cross-case analysis presented in Chapters 4 and 5. The key findings are discussed according to the RQs. Section 6.2 lists the key findings and Section 6.2.1 discusses findings in relation to RQ1. It discusses the development of the fives-stage SCRES building model in terms of the fifth stage added and the two additional stages discovered in this model. Section 6.2.2 related the findings to RQ2 and discusses the three main performance indicators of successful SCRES building. Section 6.2.3 relates to RQ3 and discusses support between SCI types, SCI orientation and

relevance of SCI with the government for SCRES building. Section 6.2.4 presents the additional discovery of trust as a practice supportive to SCRES building.

Section 6.3 focuses on how the current research findings relate to past literature and its implications. Recommendations and practical implications for each major stakeholder are presented in Section 6.4, Section 6.5 discusses contributions, and Section 6.7 summarises the chapter.

6.2 Key Findings

An overview of the key findings in relation to the three RQs is presented below and discussed in more details in the following sub-sections.

RQ1: How do SCRES building practices compare with existing SCRES building model from the literature?

- The four-stage SCRES building model was found to need adaptation; therefore, a five-stage model was developed.
- Two additional operations within SCRES building model were identified, namely Early Anticipation and Opportunistic Operations.

RQ2: What are the performance indicators of successful SCRES building process that should be included in the measurement of SCRES?

- Three SCRES performance indicators were identified: time needed to restart operations, time needed to reach full recovery and the financial damage caused by natural disaster. The latter was suggested for employment in SCRES measures.

RQ3- How is SCI utilised to support successful SCRES building?

- Operational SCI is confirmed to support SCRES building, and Relational and Informational SCI were discovered to support Operational SCI.
- Different SCRES building stages employed different SCI type and orientation (a comprehensive overview is provided).
- SCI with the government is identified as important for support of SCRES building.

Additional finding:

- Discovery of trust as additional supportive practice for SCRES building.

6.2.1 Key findings in relation to RQ1—SCRES building model

RQ1: How do SCRES building practices compare with existing SCRES building model from the literature?

In the present study, the SCRES building model from Scholten et al. (2014) was initially employed and later expanded based on the research conducted. The adaptation was undertaken in two different ways. First, the original four-stage SCRES building model was expanded to five stages, by adding a new stage, *Reconstruction*. Then, two new operations within the model were discovered: Early Anticipation within the *Preparation* stage and Opportunistic Operations during the *Initial Response* stage (see Figure 6-1).

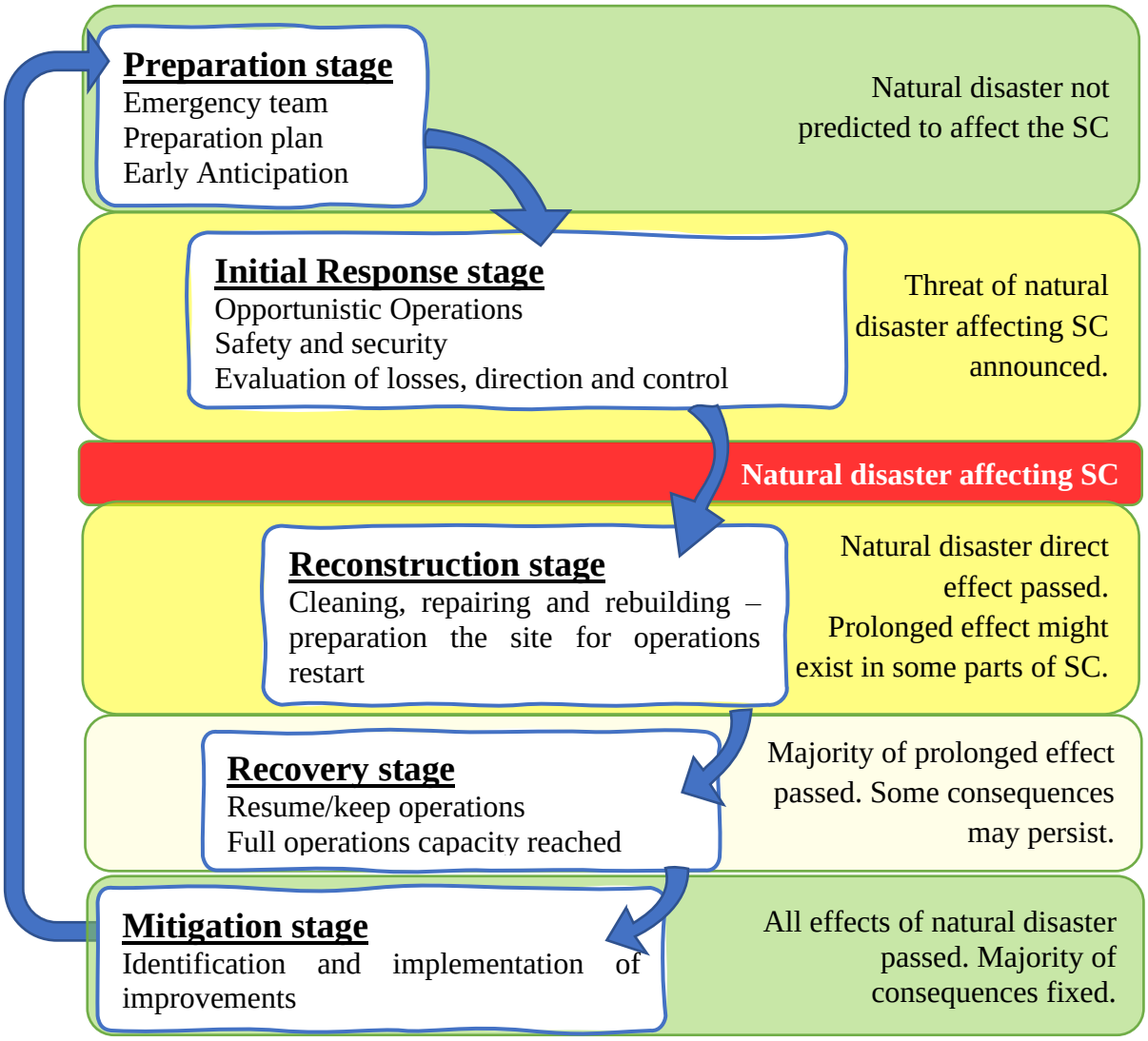


Figure 6-1*: SCRES building model with stages in relation to natural disaster effect on SC*

Five-stage SCRES building model development

In the present study, *Reconstruction* is identified as a separate stage from Scholten et al.'s (2014) model. This is based on the finding in this research that identifies significantly different operations taking place during the *Reconstruction* stage and stages before and after it (*Initial Response* and *Recovery* stages). Results from the within-case analysis (see Chapter 4) suggest separating the *Reconstruction* stage, as the findings indicate that the affected SC gets severed and the DAO stops cooperating with other organisations during the *Reconstruction* stage. For example, buyers of the DAO find another temporary supplier until the DAO is ready to restart operations, and T&L service providers and suppliers wait for the DAO to reconstruct and restart operations, hoping the DAO will make up for the time they have not operated with increased demand for transport and supplies.

Further, when overall SCI is examined in the cross-case analysis, it is found that the effect of the natural disaster reaches the widest scope in the SC during the *Reconstruction* stage. SCI with government expands from only information exchange during the *Initial Response* stage, to cooperation in the *Reconstruction* stage.

The introduction of the *Reconstruction* stage was also confirmed by analysis of multiple secondary data sources, such as news reports and reports from the United Nations and other humanitarian organisations (Wallemacq & House, 2018). Therefore, it appears the decision to distinguish the *Reconstruction* stage from the *Recovery* stage has been implicated by humanitarian organisations earlier; however, this has not been recognised in the OSCM research.

As part of SCRES building, the findings indicate that some companies perform simulations in the *Preparation* stage, yet this has not been accordingly observed in the existing literature. In addition to risk assessment in terms of financial damage and probability of the disruption occurrence, SC managers described rehearsing preparation plans, imagining disruption happening, developing different scenarios and evaluating the success of SCRES building depending on assumed outcomes of developed scenarios. In such simulations, the SCRES building success would be evaluated in relation to three performance indicators (time needed to restart operations, time needed to reach full recovery and financial impact of the disaster). However, significant insights on SCRES building were enabled only through the experience of SCRES building itself. Before a company faces a natural disaster and is forced to conduct SCRES building, rather than imagine it, SC managers described their inability to gain some of the relevant learning.

Within the *Mitigation* stage of SCRES building, findings reveal learning experience can be utilised but must be examined and applied carefully. For example, in some cases companies that had faced a natural disaster before assumed future disasters would not exceed previous ones in intensity. These assumptions had placed their entire stock in danger and caused significant losses, because management did not consider observing longer periods in the past and larger magnitude disasters to gain lessons. Therefore, the study finds that implementation of long-term learning in the simulation during the *Preparation* stage can have important benefits. Moreover, some companies faced limitations in implementing learnings. For example, it was implied during the *Mitigation* stage that new communication systems or protocols are necessary to prevent losses, as the only losses generated in one of the examined SCs were caused by a deficiency in information exchange. However, this learning has not been implemented because of the bureaucratic limitations in the examined SCs. The decision not to implement new communication systems also appears to depend on the amount of losses generated. In the SC where significant losses were generated, information exchange patterns were changed.

The question of the magnitude of the disaster remains important for managers as they do not want to capture large amounts of the company's capital in preparing for a catastrophe that may never occur.

Identification of two additional operations within the SCRES building model

The adapted five-stage SCRES building model also includes two new operations identified in this study: Early Anticipation and Opportunistic Operations.

Early Anticipation was discovered only within the SCRES building process of SCs that had previous experience with seasonal natural disasters, such as monsoons, typhoons, cyclones and hurricanes. These SCs expected the effect of the disaster to occur upstream in their SC, affecting their supply line and subsequently delaying or damaging deliveries. However, they did not expect the effects to reach their buyers. The response in this case is to build additional stock for the purpose of buffering the effect of the anticipated seasonal natural disaster. This way, the unaffected buyers maintain their demand and a supplier that has extra stocks is able to address that demand.

Opportunistic Operations was identified only in the SCRES building process of SCs that expected the disasters' effect on the SC to be more than three days in advance. In some cases, SC managers indicated that the warning had been announced but the strength of the

disaster was not identified accurately. In addition, some SC managers described ignoring warnings due to previous experiences and being confident the disaster would not reach their location. These two reasons made the disaster's effect unexpected, therefore eliminating the chance for Opportunistic Operations.

While Early Anticipation took place during the *Preparation* stage, before any natural disaster was even announced, Opportunistic Operations were performed during the *Initial Response* stage (see Figure 6-1), just before the disaster was expected to affect the location and it was still safe to operate. In these situations, organisations would produce and ship as much as possible, with the aim to generate extra profits and minimise the amount of goods stored at the location that may be damaged by the disaster. The extra profit generated in these cases was planned to be utilised for reconstruction and faster restart of operations.

6.2.2 Key findings in relation to RQ2—Three SCRES performance indicators

> ***RQ2:*** What are the performance indicators of successful SCRES building process that should be included in the measurement of SCRES?

In answering RQ2 and identifying performance indicators of SCRES building that can serve to measure SCRES, the current study had to examine the goals of SCRES building as a process. The findings identified three main performance goals that correspond to three main performance indicators that are utilised to evaluate SCRES in practice (see Table 6-1).

Table 6-1*: SCRES building goals and corresponding SCRES performance indicators*

	SCRES building goal	SCRES performance indicators
1	Reduce time needed to restart operations in any capacity	Time needed to restart operations in any capacity.
2	Reduce time needed to reach full capacity of operations; that is, reach full recovery	Time needed to reach full recovery.
3	Reduce financial losses caused by natural disaster	Financial losses caused by natural disaster.

Depending on the effect of the natural disaster on the specific organisation in the SC structure, SCRES performance goals were prioritised and SCRES was evaluated in the case SCs. While DAOs show interest in addressing all three goals and used all three indicators to

evaluate SCRES, indirectly affected organisations show an interest in full recovery time and financial indicators only. This is logical since these organisations had no direct effect on their site; therefore, the *Reconstruction* stage has not occurred and operations have only reduced in capacity but not severed. Organisations that were directly affected only in terms of their cargo but not at the location of their facilities did not have the goal to restart operations, since operations had not stopped. They continued operating with reduced capacity.

All three performance indicators are negative indicators, meaning that reduction in their values indicates more successful SCRES building; that is, better SCRES.

In addition to the identification of three different performance indicators that are utilised among practitioners to evaluate SCRES, the research discovered ambiguity in relation to evaluating financial losses. The uncertainty over how to evaluate financial losses may be the reason previous research has not considered this indicator.

6.2.3 Key findings in relation to RQ3—SCI utilised to support SCRES building

RQ3: How is SCI utilised to support successful SCRES building?

The significant finding in relation to SCI relevance for SCRES building is that SC managers learn how important SCI is for SCRES building only when they have actual experience of SCRES building. This occurs because SCI is not included in the regular preparation plan and it is not examined in simulations often occurring in the *Preparation* stage. The previous literature has not examined SCI practice relevance for SCRES building comprehensively, and the present study addresses this gap in the literature by examining SCI in terms of its scope, orientation and type.

Identification of relationship between SCI types and SCRES building

In accordance with previous research (Scholten & Schilder, 2015; Van Den Adel et al., 2018), this study finds that Operational SCI, which included coding for collaborative actions, is supportive of SCRES building. However, the present research also finds that Operational SCI supports SCRES, and this depends on previously built Informational SCI and Relational SCI.

The within-case analysis found that previously built Relational SCI helps relieve pressure on the organisation during the *Recovery* stage and simplifies SCRES building. This is because trusting parties do not pressure DAOs to prove they are trustworthy while they are

trying to rebuild and recover. If strong relationships are established before any indication that the natural disaster is approaching, those relationships are easily utilised to support Operational SCI that supports SCRES building in terms of joint effort invested in the recovery of the entire SC. In addition, Relational SCI was shown to be previously built on Informational SCI with the same party. Sharing information that is accurate and having frequent contact while exchanging relevant data was utilised to build strong relationships prior to the effect of the natural disaster. Those relationships were then utilised to support joint efforts on SCRES building. Contrastingly, poor Informational and Relational SCI prior to the disaster's immediate effect brought additional pressure to affected organisations and caused financial losses. This also increased the risk of the natural disaster's effect being transferred further along the SC.

Additionally, the study finds that staff turnover and internal relationships both play relevant roles in SCRES building. Long-term employees have experience in coping with natural disasters if the area they operate in is prone to them, because they have been employed in the organisation for a while. Moreover, these employees can easily coordinate their operations with acknowledging the company's limitations in terms of available options to avoid further losses and in terms of finances. Staff flexibility has commonly been observed as an advantageous capability to address risk (Braunscheidel & Suresh, 2009; Claussen, Kretschmer & Stieglitz, 2015; Fayezi & Zomorrodi, 2015; Tang & Tomlin, 2008); however, in the present study, flexibility of the workforce has been shown to hinder SCRES building.

Identification of SCI orientations supporting SCRES building

Findings of the cross-case analysis reveal that the scope of the SCI increases upstream until the *Reconstruction* stage and then increases downstream in the *Recovery* stage. It decreases again in the *Mitigation* stage, starting to increase from the *Initial Response* stage again. This overview of the scope is relevant in our understanding of the transfer of the effects of natural disasters.

The study finds that SCI between the DAO and suppliers can be utilised to support SCRES building, but this support varied among different SCs examined in the study. In some SCs, suppliers were very supportive, willing to engage in recovery of the DAO and provide resources that were not defined in their contract. In other SCs, suppliers were disengaged and interviewees described them as unsupportive. The interviewees explained that the reasons behind this might be different cultures, in the case of overseas buyer; purchasing power of the DAO; and magnitude of the impact of the natural disaster on the DAO. Suppliers were shown

to be more supportive when the DAO was their major buyer and when they were not certain the DAO would be able to recover if their support was not provided. However, SC managers also observed that strong relationships with suppliers might be utilised to overcome poor purchasing power of DAOs as a discouraging element to gain suppliers' support.

Identification of SCI with the government as important for SCRES building

In addition to Internal SCI, SCI with buyers, with suppliers and with T&L service providers, the present study also finds that SCI with the government has the potential to improve SCRES building. This was not recognised in earlier OSCM literature. Further, the study finds that SCI with the government is particularly useful during the *Reconstruction* stage when DAO and governmental organisations cooperate on achieving overall recovery of infrastructure, thereby helping the SC to restart operations as soon as possible.

However, practitioners' and governmental perspectives on this issue differ. Commercial organisation managers have the impression that public organisations are not open to cooperation, even though public institutions publish open calls for cooperation on this matter. The cooperation might contribute to governmental organisations communicating the desire to cooperate more effectively and induce an enhanced appreciation of the limits of governmental capacity on the part of firms.

6.2.4 Additional findings—Trust as supportive practice for SCRES building

In addition to the findings presented above, the present study identified that trust, trustworthiness and understanding were frequently utilised in the affected SCs to build SCRES.

The trust, as a concept, was identified under descriptions of Relational SCI, which accords with recent OSCM literature that examines trust as a driver of performance in undisturbed conditions (Nyaga, Whipple, & Lynch, 2010).

6.3 Implications of Key Findings and Recommendations for Main Stakeholders

The five-stage SCRES building model developed in the present study (see Figure 6-1), implies that companies need to adapt their SCRES building process, and that some companies are already applying it without having a specific framework outlined. Here, the practitioners are provided with a clear pathway to build SCRES that can bring significant improvements in the reduction of operational and financial consequences of natural disasters. Employment of the model is suggested to managers when planning and conducting SCRES building as a

process. Observing SCRES building as a process and not as an SC attribute helps practitioners to delegate and organise operations needed to build SCRES with a focus on specific performance goals related to particular SCRES building stages. The study has shown that SC managers focus on different goals while performing particular stages of SCRES, and measure how well they reached those goals to evaluate resilience.

The adapted model recognises a new stage, *Reconstruction*, which is particularly important due to the extensive transfer of a disaster's effect that occurs in this stage. It is necessary for practitioners to understand that the effect of the disaster might be transferred onto their own organisation a few days after the initial effect on the SC has occurred, depending on how well the DAO addresses the initial effect. Therefore, practitioners should focus efforts in the *Reconstruction* stage with the purpose of minimising the time needed to restart operations and consequently minimise the unnecessary transfer of effects to the rest of the SC.

The adapted five-stage SCRES building model recognises two operations of Early Anticipation and Opportunistic Operations that were shown to be particularly important for SCRES building in commercial and public organisations. The discovery of these two operations also shows that organisations can adjust operations within SCRES building stages depending on the circumstances they face. For example, organisations that receive warning of a natural disaster threat more than three days before the direct impact can operate opportunistically and generate profit valuable for faster recovery. Organisations paying attention to specific contingencies that enable additional operations may get an advanced position in the market by conducting these operations and consequently recover faster than their competitors.

The study finds that companies perform simulations in the *Preparation* stage, based on learnings gathered in the *Mitigation* stage of SCRES building. However, companies tend to anticipate only low levels of intensity of disaster and rehearse simulations accordingly. It is suggested that SC managers select what they learn from the experience carefully and employ long-term perspectives on learning in the *Mitigation* stage. This means that experience also teaches managers that disasters vary in their intensity, and the strategies to address various magnitude of disasters need to be adapted in the simulations within the *Preparation* stage. Therefore, with acknowledgment of the longer period of experience in the past, the decisions made have to distinguish between the magnitude of disaster that is worth investing in and the magnitude for which it is simply unprofitable to prepare. This decision is particularly important for small companies that have to be exceptionally careful with capital distribution.

The study identified three performance indicators SC managers use to evaluate the success of SCRES building. The first performance indicator practitioners used to evaluate SCRES—time needed to restart operations in any capacity—enables organisations to focus on specific goals of SCRES building, and limit the transfer of the disaster's effect along the SC. The importance SC managers placed on this goal once again emphasises the significance of the *Reconstruction* stage as a separate stage, because all the operations taking place during this stage are focused on addressing this performance indicator. The longer a DAO takes to reconstruct, the more probable and more severe the effect becomes for its buyers, suppliers and T&L service providers. Buyers might run out of stock, T&L service providers will have to wait longer to provide services and generate revenue, and suppliers will have excess capacity/stock.

The more affected the buyers and suppliers are, the less likely they are to support the DAO in reaching full recovery when it starts operating. Also, the longer the DAO takes to reconstruct, the more severe the effect of the disaster on the DAO. In this instance, competitors may see opportunities and gain the trust of buyers whose needs are not being met, and suppliers and T&L service providers may look for other organisations with whom to work.

The fact that practitioners tend to utilise all their performance indicators to evaluate SCRES suggests that some organisations may already have sophisticated measures of SCRES that enable them to address SCRES building in the most effective manner.

The ambiguity around the financial performance indicator of the SCRES means that different firms measure damage caused by natural disasters in different ways. While some put extra effort into measuring multiple losses, such as in terms of tangible losses, lost opportunity, paid workforce etc., it may be the case that one single measure of financial damage can capture this indicator best. This implies that organisations utilise all three performance indicators to measure SCRES and need to utilise a specific financial indicator depending on their company mission.

The findings also reveal that SCI's importance for SCRES building becomes obvious to SC managers only when they have already had experience responding to natural disasters. Therefore, this finding is especially relevant for practitioners who have not faced natural disaster before. It is suggested that SC managers pay particular attention to SCI practices and it is relevant to account for the examination of those practices in simulations performed within the *Preparation* stage.

The study also finds that all relationships in the SC are important for SCRES building. This includes relationships within one company, between private companies, between companies and the government and between companies and the community. These relationships were utilised in the past to support teamwork and invest effort in SCRES building. When acknowledging the important role of Operational SCI in supporting SCRES building and the finding that Operational SCI is supported by Relational SCI, and Relational SCI is supported by Informational SCI, the findings suggest that only organisations that have certain levels of all three types of SCI can reach the best possible SCRES.

Managers pay particular attention to staff turnover when they discuss the value of knowledge and relationships in SCRES building. Based on these findings, it is suggested that practitioners engage long-term employees in teams relevant for making decisions in SCRES building, and find ways to embed the knowledge long-term employees have on how to cope with natural disasters in the plans and practices. Moreover, long-term employees have found a way to cooperate well together and coordinate actions with acknowledgment of company limitations.

The different scope and orientation of SCI during different SCRES building stages definitely depended on the disaster's effect on specific parts of the SC. The orientation and scope variation mean that SCRES building does not solely rely on SCI type, as the orientation of SCI is also relevant. For example, during the *Initial Response* stage, the DAO interacts with its suppliers, T&L service provides and its buyers. However, during the *Reconstruction* stage, SCI between the DAO's supplier and their T&L service providers was also found to be supportive of SCRES building. Moreover, during the next stage, *Recovery*, SCI between first-tier buyers and second-tier buyers becomes important for SCRES building. Therefore, it is recommended that managers build strong relationships internally and with external stakeholders because these relationships can be utilised in particular SCRES building stages. It is suggested to build these relationships in advance before any awareness of the natural disaster approaching. Particularly in terms of orientation, SCI between the DAO and suppliers is shown to vary among different SCs facing natural disasters. However, it was shown that the relationship between the DAO and supplier plays a significant role in this, and if strong relationships are formed before the natural disaster, they might be utilised to gain support from suppliers in the case of a natural disaster. Therefore, it is suggested that managers pay particular attention to relationships with suppliers and include evaluation of that relationship in their preliminary simulations in the *Preparation* stage.

The study found that bureaucracy created limitations for some of the learnings to be implemented effectively. It also appears that the absence of serious losses limited the motivation of managers to face bureaucratic challenges and enforce implementation of the learnings. However, this implies that managers might wait until significant losses occur to create sufficient motivation to implement the learning. Consequently, it is suggested that companies make exceptions in company policies and procedures, since the absence of fast communication may cause them significant losses in terms of finances and human lives when relevant messages are not communicated in a timely and accurate manner during natural disasters.

The findings reveal the importance of SCI with governments for SCRES building. This means that organisations cooperating with the government have an opportunity to be the first ones to reach the market and gain an advantage over competitors in a similar situation. Contrastingly, disappointment in governmental engagement found in this study might mean that organisations will decide not to cooperate and communicate with the government. This may result in further widening the gap between these two parties, reducing understanding among them and affecting policies and available funds for recovery of businesses. However, the disappointment businesses expressed in the government's effort to cooperate contrasts with their claims that they heavily rely on information the government provides and on cooperation when it was needed. This may mean that companies lack an understanding of the limitations of governmental agencies. The findings also suggest that the government would benefit from closer cooperation with private companies in resilience building for the entire region, but governmental reports appear to be created based on the impression that the private sector is not interested in cooperating in all SCRES building stages. Therefore, it is advised that the private sector and public sector improve communication to address the misunderstandings outlined above. This may be particularly relevant in cases where local companies employ a significant number of local community members or handle product relevant for the local economy. Understanding what those businesses need to improve their resilience and recover faster might be crucial for recovery of the entire region. Conversely, understanding the government's limitations and discovering how to work around those limitations can significantly improve cooperation of the private and public sectors on overall resilience building. Hence, it is suggested that the government more clearly communicates its intent to collaborate with private companies and firms make a greater effort to understand the limitations confronting governmental agencies.

Governments working with private companies and the community should discuss SCRES building at the level of the region. This can be facilitated by local educational institutions offering workshops and other training programs.

Lastly, within-case analysis highlighted the lack of funding for local small businesses caused by limited communication between small businesses and governmental agencies. Therefore, it is suggested that governments initiate contact with small companies operating in their jurisdiction to evaluate the challenges these companies face and try to address them more effectively.

The findings in relation to community integration in local SCs suggest it may be possible to improve the overall resilience of an affected region. This means more effective SCRES building for the private sector and resilience building for the public sector, resulting in more stable organisations and jobs for the local community. Acknowledging this possibility, it is suggested there is a need for local communities to communicate with local businesses more effectively about their wish to contribute knowledge and other resources when addressing natural disasters. This can be achieved by local communities establishing close links with the government and non-government organisations (NGOs), and holding meetings to share knowledge and experience.

Interviewees in this study did not particularly address NGOs in their discussion of SCRES building in relation to natural disasters. This suggests companies might not be aware of the potential benefits of cooperating with NGOs. Therefore, it is suggested that managers initiate communication with NGOs and explore possibilities of cooperation on resilience building. In addition, it is suggested that NGOs work more effectively to improve private companies' awareness of how their involvement might bring more efficient SCRES building and enhance the overall resilience of SCs in the affected region. This may include developing initiatives that bring community members, governments and the private sector together to discuss the possibility of cooperation on resilience building. Local knowledge held by the community can be applied in organisations; therefore, including the community in SCRES building and companies' fast recovery has many advantages. In return, companies that apply insights from the community will recover faster and provide a more stable source of jobs for community members. Community engagement should be strongly supported in the actions of NGOs in relation to resilience building.

Trust was discovered as an additional supportive practice for SCRES building. This finding again highlights the importance of relationship building in the SC. Therefore, it is strongly suggested that managers build strong relationships with all relevant stakeholders as these relationships can be utilised during SCRES building.

6.4 Contributions and Research Model

The present research contributes to existing literature on SCRES in a number of ways (see Table 6-2). First, previous research has been inconsistent in terms of the models utilised to research SCRES, particularly in the context of natural disasters. Nineteen different models were identified in the literature and discussed in Chapter 2 of this thesis. These models disagree in terms of the number of stages, their conduct in relation to natural disasters' effect on SCs, and terminology. In addition, the previous studies assume that reconstruction will occur as part of the *Initial Response* stage (Linnenluecke et al., 2012), and have not examined these separately.

The present research contributes to the relevant literature by developing a five-stage SCRES model for future utilisation. The adapted five-stage SCRES building model also includes two new operations, identified in this study Early Anticipation and Opportunistic Operations. These two operations have not been examined in past OSCM studies. An absence of the specific environmental contingency, such as a natural disaster, in past SCRES research has provided limited insights. By focusing on specific contingency of natural disasters, the present study provides deeper insights to address these limitations and identifies these two additional operations. Besides contributing in terms of the unique model development, examining *Reconstruction* as a separate stage enabled identification of an important performance indicator of SCRES, time needed to restart operations in any capacity.

In previous research, time to restart operations was not considered in measuring SCRES. In Brandon-Jones et al.'s (2014) study, this indicator was considered but not confirmed as an important SCRES measure. This study also overlaps other indicators for measuring SCRES, such as full recovery. Resilience is measured in terms of both time to recover operational performance as before the disruption, and how easy it was to recover to the original state. However, the Brandon-Jones et al. (2014) do not provide further explanation on what it means to easily recover; that is, whether it includes time needed, finances available, finances required in comparison with assets available, or something else.

***Table 6-2**: Key findings contributions and suggestions to main stakeholders*

No	Key findings	Contributions of the study to the literature theory:	Suggestions for practice:
1	**Five-stage SCRES building model developed**	Made case for expanding the existing four-stage SCRES model into a five-stage model of SCRES with the new stage being *Reconstruction*.	Utilise expanded model when building SCRES. Engage long-term perspective in learnings in the *Mitigation* stage. Implement long-term perspective in the simulation of preparation plans.
2	**Two operations within SCRES building discovered**	Identified two operations not previously deemed part of SCRES building: 1. Early Anticipation 2. Opportunistic Operations.	SC managers should incorporate points 1 and 2 into their SCRES strategy.
3	**Two additional goals of SCRES identified**	Expanded received understanding of SCRES goals to include: 1. Reduce time needed to restart any operations at all 2. Reduce financial impact of the natural disaster.	Evaluate SCRES in relation to reaching full capacity, beginning operations and financial impact.
4	**Identified lack of understanding of financial loss minimisation**	Evidenced that participants do not agree on how to evaluate financial impact and diversity and that confusion exists in relation to this problem.	Standardise means for evaluating financial impact and diffuse acceptance where appropriate.
5	**SCI Operational → SCRES** confirmed **SCI Informational → SCI Relational → SCI Operational** discovered	Contributed the previous literature that has not commented on this discovered relationship.	Utilise Informational SCI to build Relational SCI before natural disasters and then utilise Relational SCI to build Operational SCI that will support SCRES building during the critical time.
6	**SCI with government discovered as important for SCRES**	Identified that cooperation with the government and **close integration between SCs and the government** might improve overall resilience. Governmental documents indicate the state is interested in cooperation with SCs during all five stages of SCRES, but direct interviews reveal that SC managers believe the government is not accountable or cooperative.	Expend greater effort to build bridges to government in relation to all five stages of SCRES. Government departments should determine if needed information is communicated effectively and how communication can be improved in relation to all five stages of SCRES building.
7	**Trust discovered as additional enhancer of SCRES**	**Trust identified as an important SC practice** for SCRES building.	Organisations should build stronger relationships and trust to support overall SCRES resilience.

In addition, the current study provides an explanation on how indirectly affected organisations can operate in a reduced capacity, utilising an alternative infrastructure and/or

suppliers and buyers during the *Reconstruction* stage at the DAO. The main performance indicator for indirectly affected firms was 'time to reach full recovery', meaning similar or improved operations/capability of the SC as before the natural disaster occurred. This performance indicator was second in the priority of the DAO. Only when the DAO was able to reconstruct and restart operations in any capacity would it be concerned about reaching full recovery jointly with the rest of the SC. Identification of indicator 'time to reach full recovery' accords with the previous OSCM studies that only measured the time needed to reach full capacity as before the disaster as SCRES (Van Den Adel et al., 2018).

Moreover, the existing literature does not examine the reduction of financial losses as an indicator to measure SCRES. The present study captures financial loss reduction as a goal of the *Preparation* stage (stage 1) and the *Mitigation* stage (stage 5) related to an upcoming disaster. The goals of restarting operations and reaching full capacity of operations are related to the *Reconstruction* stage (stage 3) and the *Recovery* stage (stage 4) in an ongoing natural disaster. Practitioners understand that a longer timeframe without operations can only increase financial losses, so they often choose to invest in expensive transport and additional resources to ensure a faster restart of operations and faster full recovery. After the natural disaster has passed and its major effects have diminished, the organisation can start to review SCRES building success in operational and financial terms, examining the time needed to restart operations, time needed to reach full recovery and financial losses caused by natural disaster as part of stage 5. The results of these evaluations are used to reduce financial losses caused by an upcoming disaster within the *Preparation* and *Initial Response* stages.

Identification of all three indicators is important for the literature since it provides guidance on how to measure SCRES uniquely, while capturing all dimensions of successful SCRES building. One of the significant contributions to the existing literature is that these measurement insights were defined as performance outcomes of the already conducted process of SCRES building, not as a SC's potential to be resilient. This way, the ambiguity that exists in the literature is removed because the uncertainty of natural disasters as a contingency is considered. SCRES building cannot be measured simply by measuring SC's potential to build resilience because of the unpredictable nature of the contingency. The only way to measure SCRES is to measure the outcomes of SCRES building as a process, similar to the way operational performance of the SC is measured, after operations are conducted, products are delivered and the process is completed. Therefore, SCRES should be measured in terms of operational and financial performance outcomes of the SCRES building process. Moreover,

future research might bring clarity to the evaluation of financial losses, but this needs to be enabled by identification of financial losses as an indicator first, as was done in the present study.

The potential of natural disaster as a contingency to improve understanding of SCRES has been overlooked in previous research. Therefore, utilisation of the structural contingency theory and inductive approach in the present study enabled multiple insightful findings. In addition, previous research overlooked the possibility of applying structural contingency theory to the concept of SCI. When these lenses are applied, the structure of SCI in terms of its orientation and types within each orientation was found in this study to be the most appropriate to comprehensively examine how SCI can be utilised to support SCRES building. In the present study, SCI with suppliers, buyers and T&L service providers, and with the government and community, are examined as SCI orientation, while Informational, Operational, and Relational SCI are examined as SCI types. Structural observation of the SC (with schematic representation) and SCRES building (as a five-stage process) enabled examination of specific SCI practices (orientation and type) that are important to each of the SCRES building stages. Utilising this structural approach contingent to a specific natural disaster in context, the present study finds that the relationship between different SCI types exists, and different SCI orientations and types are being utilised differently to support each of the SCRES stages. Further, trust is inductively captured as a supportive SC practice for SCRES building.

Previous research has examined the overall influence of collaboration on SCRES, but only focused on the performance goal of time needed for full recovery (Scholten & Schilder, 2015; Van Den Adel et al., 2018). The present study extends this approach and recognises three separate performance goals—time needed to restart operations, time needed to reach full recovery and the financial loses—thereby providing a more comprehensive overview of SCRES building as a process and suitable guidance for the creation of unique measures.

Finally, the present research contributes to the existing literature by identifying trust as a relevant SC practice for SCRES building. The importance of trust has been examined in humanitarian SCs (Tatham & Kovács, 2010), but has not been examined in the commercial SCs. Trust has the potential to improve communication and coordination between organisations, even when certain actions are not captured by a contract between them (Chen et al., 2016; Minet al., 2018). OSCM researchers have started revisiting trust and connecting it with integrative practices and SC performance (Shou, et al, 2017; Świerczek, 2014), but the potential

of trust to influence SCRES building against natural disaster has been overlooked in the OSCM literature.

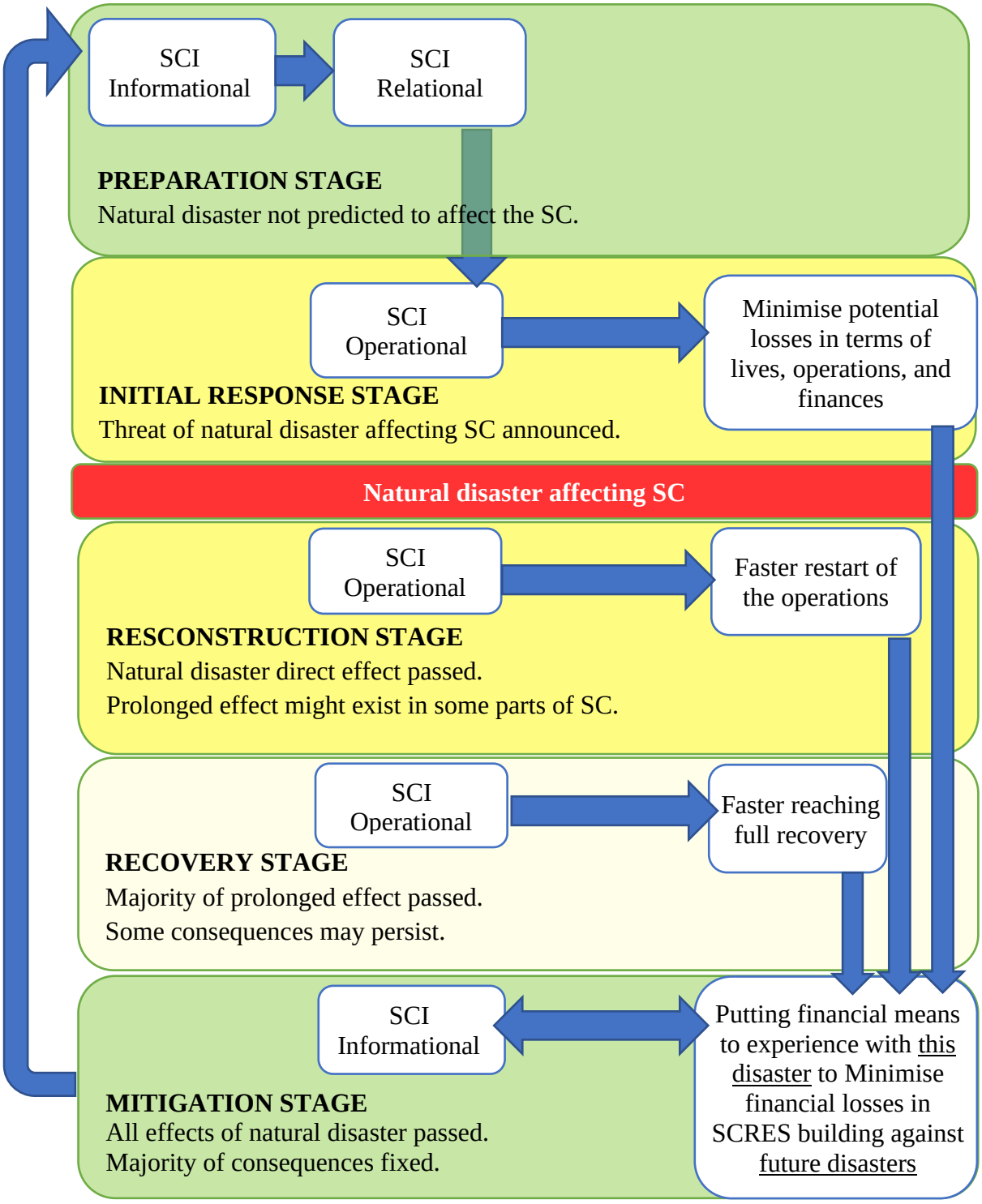


***Figure 6-2**: SCRES and SCI research model*

Based on the contributions discussed above and the key findings presented earlier in this chapter, the comprehensive research model presented Figure 6-2 captures SCRES building

stages, the performance goals, a natural disaster's effect on SC, and SCI practices supporting each particular stage. This model contributes to the extant literature by capturing key concepts that can be further researched in future studies.

6.5 Chapter Summary

This chapter has provided an overview of the research objectives, the research questions and the related findings. The major findings are discussed in terms of their implications, theoretical contributions are presented, and practical suggestions are made for all relevant stakeholders.

The next chapter presents the study's conclusions based on the research findings and discusses the study's limitations. It also provides suggestions for future research.

CHAPTER 7: CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

7.1 Introduction

Existing challenges in research on SCRES include the absence of a unique measure of the resilience utilised and a clear distinction between SCRES building as a process and SCRES as an outcome of that process. Understanding of the structure of SCRES and additional SC practices that might be utilised to support SCRES, such as SCI, need deeper understanding. The present research addresses all these challenges.

In addition to theoretical challenges, practical challenges, such as a natural disaster's unpredictability imposing a great threat on the SCs, have increased the pressure on researchers to examine these concepts in relation to natural disasters. In the 21st century, such disasters are more unpredictable and more severe than in the past, and with international trade extending the scope of SCs around the world, the latter are more vulnerable and exposed to the effect of disasters that happen globally.

In order to address the challenges identified in the literature and acknowledge the specific contingency of natural disasters, the present research utilises structural contingency theory (Donaldson, 2001) to conduct multiple case studies in a collective manner, following Yin's (2009) suggestions for cross-case analysis and Eisenhardt's (1989) guidance on within-case analysis. In doing so, this study answers multiple calls for research to examine SCRES as a contingent phenomenon (Van der Vegt et al., 2015) and confirms that a contingent approach has the capacity to bring additional insights relating to SCRES.

The multiple case study design used in this research captures 13 different natural disasters that occurred globally, as an environmental contingency dictating SCRES building and SCI utilisation in that process. Within 13 different contexts of natural disasters, 22 different SCs are examined as affected SCs, building resilience against the disaster in context.

The research set the following objectives:

Objective 1: determine how SCRES building works in practice and expand on the existing SCRES models

Objective 2: identify and describe performance indicators of successful SCRES building as a process and provide guidance for the development of a single, unique SCRES measure

Objective 3: clarify how SCI is utilised to support successful SCRES building and create a model that captures SCRES building, measurements insights and SCI that supports SCRES for the future research.

The study addressed these objectives by answering the following RQs:

RQ1: How do SCRES building practices compare with existing SCRES building models from the literature?

RQ2: What are the performance indicators of successful SCRES building process that should be included in the measurement of SCRES?

RQ3: How is SCI utilised to support successful SCRES building?

This chapter presents the study's major conclusions and suggestions for future research in relation to the key findings (see Table 7-1) and study limitations.

7.2 Key Findings and Future Research Suggestions

7.2.1 Adapted SCRES building model in relation to natural disaster

Motivated by the inconsistency in the literature regarding the SCRES models utilised in research, the present study examined Scholten et al.'s (2014) four-stage SCRES building model and extended it to a five-stage model that was shown to be appropriate for understanding and examining SCRES in relation to natural disasters. The extended model distinguishes the *Reconstruction* stage from the *Recovery* stage and recognises two additional operations previously unexamined in the OSCM literature: Early Anticipation and Opportunistic Operations.

It is suggested that future research quantitatively test this SCRES model. This may be particularly useful to improve understanding of the role of SCI in SCRES building in a specific stage.

***Table 7-1**: Key findings and suggestions for the future research in relation to RQs*

No	Key findings	Suggestions for the future research
RQ1: How do SCRES building practices compare with existing SCRES building model from the literature?		
1	**Five-stage SCRES building model developed**	Test expanded model in quantitative research.
2	**Two additional actions within SCRES building discovered: Opportunistic Operations and Early Anticipation**	To examine these practices in detail and provide additional insights.
RQ2: What are the performance indicators of successful SCRES building process that should be included in the measurement of SCRES?		
3	**Two additional goals of SCRES identified, three goals in total:** **Fast restart of operations** **Fast reaching of full recovery** **Financial losses minimisation**	To analyse these three goals in quantitative studies.
4	**Identified lack of understanding of Financial losses minimisation**	Develop new means to evaluate the financial impact of natural disasters on SCs.
RQ3 - How is SCI utilised to support successful SCRES building?		
5	**SCI Operational → SCRES** confirmed **SCI Informational → SCI Relational → SCI Operational** discovered	To test these relationships and quantify them.
6	**SCI with government discovered as important for SCRES** **SCI with government findings contradictive in terms of interest to cooperate**	To research potential of the SCI with the government to influence SCRES building and quantify it. Investigate reasons for opposite impressions from SCs managers and government.
7	**Trust discovered as an additional enhancer of SCRES**	Research the role of trust in SCRES building and quantify its character and impact.

The additional operations of Early Anticipation and Opportunistic Operations should be examined in future qualitative and quantitative research. The present study found that these operations can significantly affect performance indicators of SCRES building, that is, the effectiveness of building SCRES. Further, the study found these operations are enabled by specific contingencies, such as Early Anticipation only being applicable in seasonal events and when buyers are not expected to be affected by the natural disaster. Future studies should examine the presence of other contingencies, as well as whether this operation could also be performed for non-seasonal events. The study found that the contingency dictating Opportunistic Operations was receipt of warnings about the disaster happening three or more days in advance of the initial direct impact. Future research should investigate whether

additional contingencies exist and how companies can improve their conditions to employ this operation.

Moreover, future research should dedicate notable attention to examining the *Reconstruction* stage, especially as this stage has not been examined as distinct in previous studies. The present study found the *Reconstruction* stage operations were performed with a focus on addressing the performance indicator (i) time needed to restart operations. This implies that the management is aware that the consequences of delays occurring in this stage can be terminal for the SC operations and entire SCRES building. The indicator (i) time needed to restart operations also influences other two performance indicators: (ii) the time needed to reach full recovery, and (iii) financial losses occurred as an outcome of the natural disaster, making effectiveness in performing the *Reconstruction* stage fundamental for the success of the entire process of SCRES building.

Findings of the within-case analysis revealed that firms perform simulations of the crisis as part of the *Preparation* stage. Since these simulations have not been previously examined in the OSCM literature, it is suggested that future studies examine these comprehensively. Simulations include imagining scenarios of facing a disaster, rehearsing the response to it and evaluating the outcome of SCRES building against those responses to ensure existing plans would be effective. Managers found these simulations valuable in terms of enabling learning from experience without experiencing the disaster and suffering real losses, and in terms of bringing employees together and building all three types of SCI that have been found and confirmed as relevant to support SCRES building in the real disaster. However, learnings from an imagined crisis is very limited and the present study found that even learnings from experiences in facing a real natural disaster must be applied carefully. The *Mitigation* stage entails evaluation of effectiveness in SCRES building against a natural disaster that has ceased in operational and financial terms. In this stage, managers gained insights on the natural disaster and on their firm's response effectiveness, and those insights were implemented in the preparation plans to be applied in the future. In relation to insight on the natural disaster, the question of balance between the magnitude of the disaster a firm prepares for and the financial assets that will be captured by this preparation remains an important issue. Future research should address the issue of this balance and provide clearer guidance for managers on this matter. When gaining insights on their firm's response to a natural disaster, some companies were unable to implement relevant learnings, such as the need for a centralised and faster communication system. This study found that this was justified as obstacles related to long

bureaucratic procedures. However, it was also implied in this study that the losses generated as a consequence of the inefficient communication procedure were not substantial; therefore, the motivation to overcome bureaucratic challenges was insufficient. Future research should examine the motivation and ways to overcome similar challenges in implementing relevant learning from experience in SCRES building, and while doing so emphasise the importance of preventing serious losses should significant insights be ignored.

Findings from the present study show that organisations in a SC might go through different SCRES building stages depending on the development of the natural disasters' effect throughout the SC. This has not been identified in earlier research and was enabled in this study by taking a structural contingency approach. Relying on this approach, the structure of the SCRES building (stages) was examined in relation to the SC structure. This finding is crucial, as it clarifies the need for future research to examine specific operations within each SCRES building stage, as well as SCI practices employed to support each specific stage. The identification of the exact SCRES stage the organisations are going through and identification of SCI utilised to support that particular stage thereby produces comparable results, leading to generalisability in quantitative studies.

In conclusion, by recognising the structure of the SC and how the effect of the natural disaster is transferred along the SC, the present study suggests that future research should examine possible interdependencies between the stages conducted in different organisations depending on the transfer of this effect.

7.2.2 SCRES measure—Performance indicators of SCRES building

The present study finds three main performance indicators of successful SCRES building, that should be used to measure SCRES: (i) time needed to restart operations in any capacity, (ii) the time needed to reach full recovery, and (iii) financial losses occurred as an outcome of the natural disaster. These indicators have already been utilised in practice to evaluate SCRES building success and gather learnings from past experience with the disaster. Therefore, it is suggested that future research analyse these three indicators and develop a measure of SCRES that includes them.

Moreover, future research should develop a new means to evaluate financial losses as the present study finds inconsistency in this practice. The majority of SC managers show uncertainty on how to evaluate financial losses, with most companies using different

approaches. Evaluation of financial losses needs to be more clearly explained by future research and accordingly applied in future reports of private and public organisations.

7.2.3 SCI utilised to support SCRES

The present study finds that the true value of SCI can only be revealed to managers after the firm has experienced a natural disaster. This occurs because SCI is not examined as a relevant factor during simulations in the *Preparation* stage. In this study, SCI practices were discovered as crucial for supporting SCRES building in relation to natural disasters. Moreover, the study finds different orientations and types of SCI are being utilised to support each SCRES stage. Therefore, future research should examine these orientations and types in detail to determine possible interdependencies in these relationships. It should also guide practitioners on how to implement SCI as a relevant factor in the simulations performed in the *Preparation* stage of SCRES building.

The study confirms that Operational SCI (i.e., collaboration) will support SCRES building (Scholten & Schilder, 2015; Van Den Adel, Scholten, & Van Donk, 2018). However, the study also identified that Informational and Relational SCI are necessary to build Operational SCI. It is suggested that Informational and Relational SCI should be built prior to any known effect of a natural disaster taking place. Therefore, it is suggested that future research test and quantify these relationships so the real potential of Informational and Relational SCI to support Operational SCI and SCRES can be better understood. Building on these findings, the study also finds that the support suppliers provide to DAOs varies depending on the purchasing power of the DAO, different cultures of a DAO and its supplier, and the supplier's views of whether the DAO needs help or will recover without the supplier's assistance. Findings imply that strong relationship with suppliers can be utilised to overcome these limiting factors. Future research should examine if there are more factors limiting suppliers' support and examine how these relationships can be utilised to overcome them.

Findings of this study revealed that flexibility, previously highly valued in the literature for SCRES, is not appropriate for all practices that might influence SCRES. For example, flexibility in relation to the workforce was found to hinder SCRES building, since it made building and maintaining internal relationship difficult. Long-term employees have a sense of ownership with the firm, they build strong relationships among one another and they hold relevant experience in facing natural disasters or similar crises from the past. These employees are willing to invest more effort in the firm's recovery and their effort will be coordinated,

based on previous learning and knowledge of the SC's limitations in responding to the natural disaster. Therefore, future research should investigate how staff turnover influences Internal SCI and SCRES building and examine other human resources practices that might be relevant for SCRES building.

The study finds that SCI with the government can support SCRES building. In the cases where a relationship with the government was built before the crisis, SC managers were able to rely on this connection and cooperate with the government on the overall recovery of the region, including SCRES building for businesses, community and public organisation. The government agencies were also found to be reliable in terms of the information they provide to organisations and management tends to depend on this information when making crucial strategic decisions for recovery. Therefore, it is suggested that future research investigate and quantify this relationship. Notably, this study found contrasting interpretations from public and private organisations regarding this relationship. While managers found government to be not overly interested in interaction and cooperation on SCRES building, the government reports clearly identify a lack of interest from the private sector on this matter. Future research should investigate the reasons behind the conflicting impressions of SCI from governmental bodies and private organisations.

SCI with NGOs and communities presents an interesting area to be researched in the future. Besides utilising local knowledge in some SCs, the present study has not found other cooperation between private organisations and the community to build resilience. Therefore, it would be fruitful if future studies examine possible ways in which NGOs, communities and private companies could cooperate on resilience building.

7.2.4 Trust utilised to support SCRES

The present study inductively captured trust as an additional practice that is being utilised to support SCRES building. In this study, trust was mostly described as part of Relational SCI and how Relational SCI was utilised to support Operational SCI in building SCRES. This suggests that trust interacts with SCI in SCRES building. It is suggested that future research examine how trust, as a practice, supports SCRES building, and quantify this in different SCRES stages. Future studies should also examine the relationship between trust, SCI and SCRES, and quantify it.

7.3 Limitations and Future Research Suggestions

The present research used data collected through interviews with managers currently residing in Australia. They described SCRES building from their position in organisations based in developed countries. Some SCs included organisations based in developing countries as suppliers or buyers of the interviewee's organisation, and the perspective of these organisations was not captured directly from the managers interviewed. It is suggested that future studies test the SCRES model in the context of developing countries as well.

In this study, one SC was described from the position of one SC manager. Future studies should include several SC managers from different organisations in one SC to describe SCRES building and utilisation of SCI to support that process. This may contribute to further understanding how natural disaster effects are transferred along the SC (upstream and downstream) and based on this, which organisations are then entering different SCRES stages. In addition, multiple informants from different positions in one SC might bring additional understanding of SCI, as well as trust, since both perspectives on the relationship could be provided.

Testing the SCRES model on more natural disasters in the future may confirm the model provided in this study and enrich it with additional insights, thereby building consistency and agreement among findings in SCRES research.

The present study included one small business. This small business never recovered and was sold to a large business as a consequence of the damage caused by the natural disaster. It might be interesting for future studies to conduct an inductive study to understand the challenges small Australian businesses face in building SCRES.

7.4 Chapter Summary

Finalising the thesis, this chapter has summarised the main issues identified as part of the literature review and described the research conducted in this study to address them. It discussed the key findings of the present study and highlighted areas for future research. The limitations of the present study are also identified.

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APPENDIX A: INVITATION LETTER

MONASH University
Business and Economics

Resilient supply chains and extreme weather events

Invitation to participate in a Monash University study about supply chain resilience following extreme weather

Extreme weather poses major risks to global supply chains and business performance. Weather patterns are changing and their effects on businesses are increasingly significant which require supply chains to be well prepared. Extreme weather can cause major production and distribution disruptions. Costs can be borne from lost sales, infrastructure and inventory losses (among others). We are conducting research on the resilience of supply chains in the event of extreme weather.

This research aims to identify reasons why some supply chains recover quickly and successfully, while others suffer significant, long-term impact from extreme weather.

We aim to support supply chain members to better adapt and improve their resilience to extreme weather events. To do this, we seek to combine our expertise in supply chain management with your experience before and after extreme weather events.

We will only need 30 minutes of your time to discuss your experiences with extreme weather event and recovery. The discussion will be confidential and neither your name nor your organisation details will be identified in any of our data.

We will provide a summary of the outcomes of this study to you once it is complete. The summary will provide insights on how your business and other businesses currently perceive and manage extreme weather events, as well as the issues they see with responding and recovering from such events.

To participate in the study, please contact Adela Drozdibb or Dayna Simpson as below.

Monash University Faculty of Business and Economics Management Department	
Assoc. Prof. Dayna Simpson Email: Dayna.Simpson@monash.edu Phone : +61 3 990 32674	Adela Drozdibob Email : Adela.Drozdibob@monash.edu Phone : +61 3 990 321 62

Best Regards,

Chief Investigator: Dayna Simpson

Research student: Adela Drozdibob

APPENDIX B: SECONDARY DATA SOURCES

***Table AB-1**: Context of Queensland floods (2008)*

Queensland floods (2008) – QLD, Au
Newspaper online article
Furler, M. (2008). Mackay: The flooded city, Sunshine Coast Daily. 2018. Robinson, G. (2008). Mackay declared a disaster zone. Sydney, NSW, The Sydney Morning Herald. 2018. Clean up begins after Mackay flooding. (2008, 16/02/2008). text. Retrieved from http://www.abc.net.au Hicks, S. (2008, 27/02/2008). "Mackay Floods 2008." Retrieved 15/11, 2018, from http://www.abc.net.au/local/stories/2008/02/20/2167581.htm Hicks, S. (2008, 19/02/2008). "Clean up insanity 1." Retrieved 15/11, 2018, from http://www.abc.net.au/local/photos/2008/02/18/2168134.htm?site=tropic. Hicks, S. (2008, 19/02/2008). "Clean up insanity 2." Retrieved 15/11, 2018, from http://www.abc.net.au/local/photos/2008/02/18/2312275.htm?site=tropic.
Audio-visual material - News
Eeles, S. (2008). Queensland floods. Mackay, QLD, Sky News. O'Connor, A. (2008). Mackay declared disaster zone. Mackay, QLD, ABC News. Arnold, E. (2018). 10 years on - Mackay 2008 floods. Mackay, QLD, Seven News.
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Hall, E. and M. Watson (2008). The world today: Flash floods hit Mackay. Mackay, QLD, ABC Local Radio.
Government Reports
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Published research papers
Apan, A., et al. (2010). The 2008 floods in Queensland: A case study of vulnerability, resilience and adaptive capacity. Gold Coast, National Climate Change Adaptation Research Facility: 171.

Keogh, D. U., et al. (2011). Resilience, vulnerability and adaptive capacity of an inland rural town prone to flooding: a climate change adaptation case study of Charleville, Queensland, Australia. *Natural Hazards* 59: 699-723. Thomas, M., et al. (2011). Resilience to climate change impacts: a review of flood mitigation policy in Queensland, Australia. *The Australian Journal of Emergency Management* 26(1): 8-17.
Interviews included in the secondary data
Anonymous business owners from Mackay area, Anna Bligh, Premier of state of Queensland, Don Rolls, deputy mayor Mackay City Council, Cr Julie Boyd, Major of Mackay, Frank Pagano, chief of Emergency Management Queensland, Neil Roberts, Minister of Queensland Emergency Services, Tim Mulherin, Mackay MP and Minister of Primary Industries, Kevin Rudd, Prime Minister of Australia, Joe Ludwig, Senator, Federal Minister for Human Services, Justin Englert, former SES officer in charge, Jeff Perkins, spokesperson of Weather Bureau, Rowan Bond, Superintendent of Mackay Police, 12 representatives from stakeholder public institutions from Mackay.

***Table AB-2**: Context of TC Tasha (2010)*

Tropical cyclone Tasha (2010) – QLD, Au
Newspaper online article
Calligeros, M. (2010, 29/12/2010). Flooding could last 'weeks, not days'. Retrieved from https://www.brisbanetimes.com.au/environment/weather/flooding-could-last-weeks-not-days-20101229-199iy.html Calligeros, M. (2010, 31/12/2010). Rockhampton food stocks plunge. Retrieved from https://www.brisbanetimes.com.au/environment/weather/rockhampton-food-stocks-plunge-20101229-19a4p.html Fraser, A., & Owens, J. (2011, 09/02/2011). Floods hit businesses nationwide. The Weekend Australian. Retrieved from https://www.theaustralian.com.au/in-depth/queensland-floods/floods-hit-businesses-nationwide/news-story/1afc621f0d8d13ea7bc9a4241645b277 'Heartbreaking' floods to cost billions. (2010, 30/12/2010). Retrieved from https://www.smh.com.au/national/heartbreaking-floods-to-cost-billions-20101230-19adw.html Reuters. (2011, 11/01/2011). Queensland flood impact fact box. Business. Retrieved from https://www.smh.com.au/business/queensland-flood-impact-fact-box-20110111-19m3v.html Rockhampton Airport shuts down. (2011, 03/01/2011). online. The Morning Bulletin. Retrieved from https://www.themorningbulletin.com.au/news/rockhampton-airport-shuts-down/734779/ Timeline: Grantham and Toowoomba floods - five years on. (2016, 23/02/2018). Retrieved from https://www.abc.net.au/news/2016-01-09/grantham-floods-timeline-january-2011/7070414 Van De Wetering, J. (2011, 01/08/2011). 175 Recommendations in interim flood report. Retrieved from http://www.abc.net.au/local/stories/2011/08/01/3281253.htm
Audio-visual material—News
Bowrey, S. (2011). Queensland flood disaster [video]. Brisbane, QLD: Seven News. Clarke, E. (2010). Queenslanders mop up on Boxing Day: ABC News. Cummis, T. (2010). North Queensland cut off as floodwaters keep rising with more rain on the way. Brisbane, QLD: Seven News. Doyle, M. (2011). Queensland flood disaster - developing story. Sunrise: Special Extended Edition [video]. Brisbane, QLD: Sunrise- Australian Television. Edwards, E. (2011). Queensland floods - The aftermath in Theodore. Theodore, QLD: Seven News. Whiting, J. (2010). Queensland had its first cyclone of the summer [video]: Seven News. Wong, K. (2010). Cyclone Tasha Causes Major Flooding in the Australian State of Queensland [video]. New York, NY: NTDTV. Woods, I. (2011). 'A Disaster Of Biblical Proportions'. Australia Floods. Brisbane, QLD: Sky News.
Government Reports
ABARES. (2011). The impact of recent flood events on commodities (A. Government Ed.). Canberra, ACT: Australian Bureau of Agricultural and Resource Economics and Sciences. AIDR. (2017, April 2017). Did you know? Queensland floods 2011–2012. Retrieved from https://knowledge.aidr.org.au/resources/ajem-apr-2017-did-you-know-queensland-floods-2011-2012/ BOM. (2011). Flood summary for Brisbane River at Brisbane – December 2010 and January 2011 Retrieved from Melbourne, VIC: http://www.bom.gov.au/qld/flood/fld_reports/brisbane_fact_sheet_2011.pdf BOM. (2011). Flood summary for the Burnett River at Bundaberg – December 2010 and January 2011 Retrieved from Melbourne, VIC: http://www.bom.gov.au/qld/flood/fld_reports/bundaberg_fact_sheet_2011.pdf BOM. (2011). Flood summary for the Nogoa River at Emerald – December 2010 and January 2011. Retrieved from Melbourne, VIC: http://www.bom.gov.au/qld/flood/fld_reports/emerald_fact_sheet_2011.pdf

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BOM. (2011). Flood summary for the Dawson River at Theodore – December 2010 and January 2011. Retrieved from Melbourne, VIC: http://www.bom.gov.au/qld/flood/fld_reports/theodore_fact_sheet_2011.pdf
BOM. (2011). Flood summary for Toowoomba– December 2010 and January 2011. Retrieved from Melbourne, VIC: http://www.bom.gov.au/qld/flood/fld_reports/toowoomba_fact_sheet_2011.pdf
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Van den Honert, R. C., & McAneney, J. (2011). The 2011 Brisbane Floods: Causes, Impacts and Implications. Water, 3(4), 1149.

Interviews included in the secondary data

Alistair Dawson, Acting Assistant Commissioner of Queensland Police,
Anna Bligh, Queensland Premier,
Brad Carter, Rockhampton Mayor,
Brian Hughes, QLD Ambulance Service,
Bruce Grady, Emergency Management Queensland acting chief officer,
Bryan Rolston, Bureau of Meteorology,
Cr Tony Ricciardi, Bundaberg Deputy Mayor at time,
David Peff , Acting Superintendent, QLD Police,
Gary Boyer, Woolworths regional manager,
Greg Goebel, Red Cross Queensland executive director,
Ian Stewart, Deputy Police Commissioner,
Julia Gillard, Prime Minister of Australia,
Mick Slater, Major-General, The head of the flood recovery taskforce,
Mike Swanston, Energex spokesman,
Peter Maguire, Central Highlands Mayor,
Scott Groer, QLD fire and rescue,

Sgt Bruce Maclean, QLD Police,
Snr Const Tim Lowth, Bundaberg Police,
Snr Sgt Scott Nolan, QLD Police,
Superintendent Rowan Bond, Queensland Police, Bundaberg Police Station,
Tony Auden, weather reporter,
Vicki Shailer, station officer, QLD fire and rescue,
Wayne Swan, Australian treasurer.

***Table AB-3**: Context of Hurricane Sandy (2012)*

Hurricane Sandy (2012) affecting North Atlantic, USA
Newspaper online article
As it happened: US takes stock after Sandy. (2012, 31/10/2012). Retrieved from https://www.abc.net.au/news/2012-10-30/us-rides-out-hurricane-sandy/4342528 Blinch, M., Kukl, T., Munoz, E., Broome, G., Evans, M., Tama, M., . . . Lanzano, L. (2012). 50 dramatic images of destruction caused by superstorm and hurricane Sandy (photography). Retrieved 12/12/2018, from Telegraph https://www.telegraph.co.uk/news/picturegalleries/worldnews/9644975/Hurricane-Sandy-pictures-50-dramatic-images-of-destruction.html?frame=2383520 Bonney, J. (2012, 07/11/2012). NY-NJ Port Operating at 'Full Speed'. Retrieved from https://www.joc.com/port-news/us-ports/port-authority-new-york-new-jersey/ny-nj-port-operating-full-speed_20121107.html?destination=node/2703361 Bonney, J., & Leach, P. T. (2012, 15/11/2012). Port of NY-NJ Gets Back to Work. Retrieved from https://www.joc.com/port-news/us-ports/port-new-york-new-jersey/port-ny-nj-gets-back-work_20121115.html David, J. E. (2012, 12/11/2018). Sandy an 'Enormous Hit' to Economy: Ex-Fed Official. Retrieved from https://www.cnbc.com/id/49646288 El-Erian, M. (2012, 14/11). Sandy's Market Impact — From the Known to the Uncertain. Retrieved from https://www.cnbc.com/id/49613967 Forney, D. (2012, 29/10/2012). More than 150 people, animals seeking shelter at Cape High. Retrieved from https://www.capegazette.com/article/more-150-people-animals-seeking-shelter-cape-high/36431 Furman, P. (2013, 26/10/2013). Hurricane Sandy, one year later: Businesses struggle to survive. Retrieved from http://www.nydailynews.com/new-york/hurricane-sandy/hurricane-sandy-year-business-article-1.1493143 Hurricane Sandy fast facts. (2018, 29/10/2018). International News. Retrieved from https://edition.cnn.com/2013/07/13/world/americas/hurricane-sandy-fast-facts/index.html Hurricane Sandy special issue. (2013). Fire Engineering, 166(5), 100-103. Indy. (2012, 31/10/2012). Hurricane Sandy update on the effect to US shipping and logistics operations. text Retrieved from http://indyfrt.com/hurricane-sandy-update-on-the-effect-to-us-shipping-and-logistics-operations/ Lacey, S. (2014, 28/10/2014). Two years after Hurricane Sandy, a reminder of what utilities faced as the storm approached. Retrieved from https://www.greentechmedia.com/articles/read/two-years-after-hurricane-sandy-a-reminder-of-what-utilities-faced#gs.GYVWHpv9 Malinbaum, R. (2012, 14/11/2012). Diverted containers, international shipping. International Shipping & Freight Forwarding Blog. Retrieved from https://www.etcinternational.com/blog/bid/61188/Diverted-Containers-International-Shipping Leach, P. T. (2013, 27/02/2013). Sandy Alters Marine Insurance Climate. Retrieved from https://www.joc.com/maritime-news/international-freight-shipping/sandy-alters-marine-insurance-climate_20130227.html Malinbaum, R. (2012, 14/11/2012). Diverted containers, international shipping. International Shipping & Freight Forwarding Blog. Retrieved from https://www.etcinternational.com/blog/bid/61188/Diverted-Containers-International-Shipping McCarthy, T. (2013, 13/04/2013). 'Sandy' to be retired as hurricane name by World Meteorological Organization. Retrieved from https://www.theguardian.com/world/2013/apr/12/hurricane-sandy-name-retire McGeehan, P., & Hu, W. (2017, 29/10/2017). Five Years After Sandy, Are We Better Prepared? Retrieved from https://www.nytimes.com/2017/10/29/nyregion/five-years-after-sandy-are-we-better-prepared.html

Milman, O. (2017, 28/10/2017). Hurricane Sandy, five years later: 'No one was ready for what happened after'. Retrieved from https://www.theguardian.com/us-news/2017/oct/27/hurricane-sandy-five-years-later-climate-change
Muskal, M., & Susman, T. (2012, 30/10/2012). Monster storm Sandy marches west, leaving death, chaos in its wake. Retrieved from http://articles.latimes.com/2012/oct/30/nation/la-na-nn-hurricane-sandy-destruction-20121030
Newman, A. (2012, 10/11/2012). For the Rockaways, a ferry and some subway service. Hurricane Sandy: Covering the storm. Retrieved from http://archive.nytimes.com/www.nytimes.com/interactive/2012/10/28/nyregion/hurricane-sandy.html?smid=tw-nytimes#c5d4b7366
Reuters. (2012, 02/01/2013). Hurricane Sandy Aftermath: Anger Grows At Recovery Efforts, Especially Outside Manhattan. HuffPost News. Retrieved from https://www.huffpost.com/entry/hurrican-sandy-aftermath-recovery-anger_n_2065852
Sandy: Storm-hit New York declared major disaster area. (2012, 30/10/2012). Retrieved from https://www.bbc.com/news/world-us-canada-20137363
Sharp, T. (2012, 27/11/2012). Superstorm Sandy: Facts About the Frankenstorm. Planet Earth. Retrieved from https://www.livescience.com/24380-hurricane-sandy-status-data.html
Taylor, A. (2012, 01/11/2012). Hurricane Sandy: The aftermath. In Focus. Retrieved from https://www.theatlantic.com/photo/2012/11/hurricane-sandy-the-aftermath/100397/
Vineyard, J. (2012, 08/11/2012). Hurricane Sandy aftermath: NY/NJ ports shipping amidst wreckage. Retrieved from https://www.universalcargo.com/hurricane-sandy-aftermath-ny-nj-ports-shipping-amidst-wreckage/#

Audio-visual material—News

Sales, L., & Brissenden, M. (2012). Frankenstorm brings devastation over 1,000-kilometre front. Sydney, NSW: ABC News.
Sales, L., & Knight, B. (2012). Sheltering Americans reflect on Super Storm's impact. Sydney, NSW: ABC News.

Audio material—Radio

Colvin, M., & Knight, B. (2012). Coastal towns unable to resume services. Delaware, DE: ABC Radio.
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Andrew Mark Cuomo, New York Governor,
Barack Obama, USA President,
Chris Christie, New Jersey governor,
Christopher James Christie, New Jersey Governor,
Daniel A. Zarrilli, the city's chief resilience officer,
Daniel C. Negron, vice president of the TT Club, Thomas Miller Americas,
Dawn Zimmer, the Mayor of Hoboken,
Earl Ray Tomblin, West Virginia Governor,
Edward Blakely, Executive Director of Recovery Management for the City of New Orleans,
Geoffrey Giovanetti, managing director of the Wine and Spirits Shippers Association,
Jeff Bader, president of port trucker Golden Carriers and of the Association of Bi-State Motor Carriers – in the affected area of Sandy,
Jock Menzies, president of the American Logistics Aid Network (ALAN),
Joe Lhota, the chairman of the New York Metropolitan Transport Authority (MTA),
John Barnwell, global marine product leader at Allianz Global Corporate & Specialty,
Josh DeFlorio, the Port Authority's chief of resilience and sustainability ,
Kathy Fulton, director of operations at ALAN,
Lou Villani, Con Ed's chief engineer – Con Edison power plant,
Martin O'Malley, Maryland governor,
Michael Bloomberg, New York city Major,
Michael Marino, manager at PATH system for the Port Authority of New York and New Jersey,
Paul Friel, cargo leader for the Northeast at insurance brokerage Marsh USA Rick Peterson, Shelter manager for Red Cross in Lewes High School,
Richard Fenning, Disaster modelling expert,
Rick Larrabee, director of the port authority's port commerce department,

Robert Freudenberg, the vice president for energy and environment at the Regional Plan Association, an urban research group,
Rodney W. Oliver, interim executive director of the Virginia Port Authority,
Roslyn Weinstein, a vice president for operations for NYC Health & Hospitals,
Steven H. Santoro, the transit agency's executive director - New Jersey Transit,
The Metropolitan Transportation Authority (MTA) representatives,
Tom Connery, Chief Operating Officer at England Motor Freight Inc.,
Vincent Reinhart, chief US economist at Morgan Stanley.

***Table AB-4**: Context of TC Lua (2012)*

Tropical Cyclone Lua (2012) – WA, Au
Newspaper online article
AAP. (2012, 19/03/2012). Little damage from scary Cyclone Lua. Retrieved from https://www.smh.com.au/environment/weather/little-damage-from-scary-cyclone-lua-20120318-1ve54.html AAP. (2012). Woodside West Aust fields suspended post-cyclone. In. Rhodes: Asia Pulse Pty Ltd. Bartlett, J., & Wilson, K. (2012, 22/03/2012). Cyclone Lua brings rain without major damage. Farm Weekly, p. 8. Retrieved from http://fw.farmonline.com.au King, R. (2012, 15/03/2012). West Aust resources firms brace for cyclone. Retrieved from https://www.smh.com.au/national/western-australia/wa-resources-firms-brace-for-cyclone-20120315-1v7jw.html Bell, S. (2012). Santos stops Mutineer-Exeter oil production on cyclone Lua. In. New York: Dow Jones & Company Inc. Bell, S. (2012). Australia Port Hedland: March Iron Ore Shipments Fall To 18.66 Mln Tons. In. New York: Dow Jones & Company Inc. Brindal, R. (2012). Australian Bureau Says Cyclone Lua Moving Off Pilbara Coast. In. Canberra: Dow Jones & Company Inc. Brindal, R. (2012). Australian Bureau Warns Cyclone Lua To Intensify Turn Severe. In. Canberra: Dow Jones & Company Inc. First gas fed into Woodside's West Australian Pluto LNG project. (2012). In. Rhodes: Asia Pulse Pty Ltd. Reuters. (2012, 18/03/2012). Northwest Australia takes measures to face cyclone. Retrieved from http://www.taipeitimes.com/News/world/archives/2012/03/18/2003528099 Robertson, K. (2012, 16/03/2012). WA News: Cyclone Lua will bring destructive 200km/h winds to Pilbara coast. Retrieved from https://www.perthnow.com.au/news/wa/cyclone-lua-will-bring-destructive-200kmh-winds-to-pilbara-coast-ng-acde4973e2b5286e25307d75dceeddc9 Severe Tropical Cyclone Lua crosses WA coast. (2012, 18/03/2012). Retrieved from https://www.abc.net.au/news/2012-03-17/tropical-cyclone-lua-crosses-wa-coast/3896098 Spooner, R.. (2012, 16/03/2012). Pilbara miners brace for Cyclone Lua. Retrieved from https://www.watoday.com.au/business/pilbara-miners-brace-for-cyclone-lua-20120316-1v9fz.html Spooner, R., & Rimdor, F. (2012, 16/03/2012). Cyclone Lua gains strength as it nears WA coast. Retrieved from https://www.watoday.com.au/national/western-australia/cyclone-lua-gains-strength-as-it-nears-wa-coast-20120316-1va9f.html Stewart, R. M. (2012). Dow Jones Institutional News; New York - Update: Australia's Pilbara braces as cyclone intensifies. In. New York, NY: Dow Jones & Company Inc. Tseng, D. (2012, 11/05/2012). Port Hedland iron ore shipments to China recover in April. Metal Bulletin.
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Audio material—Radio
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Andrew Longmire, Salmon Gums farmer, Annabelle Coppin, pastoral lease and cattle station spokeswomen, BHP Billiton spokesperson, Bill Johns, Killara station, Meekatharra, Chevron Ltd. Spokesman, David Stoate, Anna Plains station, Broome, Gary Strother , Holt Rock farmer, Grahame Reader, BOM spokesperson Steed Farrell, Port Hedland Port Authority spokesman, Jim Cahill, Fire and Emergency Services Authority (FESA)- District Manager East Pilbara – Port Hedland, Lang Coppin, owner of Yarrie cattle station, Les Hayter, Fire and Emergency Services Authority (FESA) spokesman, Janet Robb, Pardoo Roadhouse manager, Neil Bennett, BOM forecaster, Pete Morris, ranger WA parks, Peter Coleman, chief executive of Woodside's Petroleum Pluto LNG project, Peter Cooke , North Mollerin farmer, Port Hedland Porth Authority spokesman, Rio Tinto Iron Ore spokesperson, Santos spokesperson, Scott Watson, Bonnie Rock farmer, Steve Bunce, a ranger at Cape Keraudren, an area that was in the cyclone's firing line, Troy Buswell, Emergency Services Minister in WA.

***Table AB-5**: Context of Marcia (2015)*

Tropical Cyclone Marcia (2015) – QLD, Au
Newspaper online article
AAP. (2015, 22/02/2015). Cyclone Marcia: Queensland towns hit by flooding as army helps in recovery. Retrieved from https://www.theguardian.com/australia-news/2015/feb/22/cyclone-marcia-queensland-towns-hit-by-flooding-as-army-helps-in-recovery AAP. (2015, 22/02/2015). Weather News - Tropical Cyclone Marcia: Gympie businesses begin to flood with water from Mary River. Retrieved from http://www.weatherzone.com.au/news/tropical-cyclone-marcia-gympie-businesses-begin-to-flood-with-water-from-mary-river/245538 BigLocal. (2015, 23/02/2015). Cyclone Marcia brings 30 year flood high - Floodwaters rose to their highest level in 30 years on 21st February 2015 in parts of Mango Hill. Retrieved from http://mangohillqld.com.au/2015/02/ Brennan, R., Honnery, C., & AAP. (2015, 20/02/2015). Cyclone Marcia: Brisbane looking at 'major flooding event'. Retrieved from https://www.couriermail.com.au/news/queensland/weather/cyclone-marcia-brisbane-looking-at-major-flooding-event/news-story/95d7c7baaf54068db4748be5fdad9a6a Hoffman, B. (2015, 06/03/2015). Cyclone Marcia cements flood mapping decisions. Retrieved from https://www.sunshinecoastdaily.com.au/news/council-learns-a-lot-from-marcia/2565691/#/0 Koubaridis, A., & AAP. (2015, 22/02/2015). Cyclone Marcia: Floods, rain as clean-up operation begins. Retrieved from https://www.news.com.au/technology/environment/cyclone-marcia-floods-rain-as-cleanup-operation-begins/news-story/37c5638aab230a49c0aa783e8b721445 Margolis, Z., & Robinson, P. (2015, 06/03/2015). Cyclone Marcia: Central Queensland businesses count cost of damage. Retrieved from https://www.abc.net.au/news/2015-03-06/central-qld-businesses-count-cost-of-cyclone-marcia/6285270 Pierce, H. (2015, 25/02/2015). NASA Adds Up Tropical Cyclone Marcia's Queensland Area Rainfall. Retrieved from https://www.nasa.gov/content/goddard/marcia-southern-pacific Pierce, H., & Gutro, R. (2015, 20/02/2015). Feb. 20, 2015 - NASA saw heavy rainfall in Tropical Cyclone Marcia Retrieved from https://www.nasa.gov/content/goddard/marcia-southern-pacific Robertson, J. (2015, 20/02/2015). Cyclone Marcia wreaks damage along Queensland coast. Retrieved from https://www.theguardian.com/australia-news/2015/feb/20/cyclone-marcia-wreaks-damage-along-queensland-coast Terlato, P. (2015, 20/02/2015). Cyclone Marcia has hit Rockhampton, bringing with it heavy rain and flooding. Retrieved from https://www.businessinsider.com.au/queensland-premier-says-its-too-late-to-evacuate-as-harrowing-and-terrifying-cyclone-hits-queensland-2015-2 Tropical Cyclone Marcia: Brisbane, Sunshine Coast to escape full impact, risk of flooding remains. (2015, 21/02/2015). Retrieved from https://www.abc.net.au/news/2015-02-21/south-east-queensland-to-escape-ex-tropical-cyclone-marcia/6172390
Audio-visual material—News
Ahmat, N. (2015). Tropical Cyclone Marcia is continuing to wreak havoc along the Central Queensland Coast. Brisbane, QLD: SBS Television, NITV News. Ahmat, N., & Grant, K. (2015). Whatever the cost of Insurance claims after Tropical Cyclone Marcia has reached an estimated $67mn: SBS Television, NITV News. Carvalho, K., & Woodward, J. (2015). Weather report: On severe Tropical Cyclone Marcia and how quickly it changes. Brisbane, QLD: ABC News. Enus, A., Petersen, J., Armbruster, S., Abbott, T., Condon, M., Shepherd, M., & Strelow, M. (2015). Frustrations are mounting in central Queensland over the recovery effort after severe Tropical Cyclone Marcia: SBS Television. Sales, L., & Lewis, D. (2015). The moment a dam's floodgates opened in the middle of a cyclone: Tropical Cyclone Marcia wreaked havoc across central Queensland last Friday, bringing with it powerful winds, a heavy rainfall and flooding but residents in the small towns of Biloela and Jambin

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ICA. (2015). Cyclone Marcia declared a catastrophe [Press release]. Retrieved from https://www.insurancecouncil.com.au

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Annastacia Palaszczuk, Premier of Australia
Bill Ludwig, The local Yeppoon Mayor, mayor of the Livingstone shire council.
Campbell Fuller, ICA spokesman
Christian Dickson, Planning portfolio head Councillor – Sunshine Coast Council
Clayton Coughlan, Queensland Fire and Emergency Services' volunteer
Colin Maxwell, Major of Rockhampton John Lewis, AIB Insurance Brokers
Gail Sellers, Gladstone Mayor
Graham Quirk, Brisbane Lord Mayor
Greg Lee, Business owner in Jambin
Ian Stewart, Police Commissioner

Joshua Cooney, Suncorp insurance spokesman
Leonie Vandeven , Brisbane Airport Corporation's
Lincoln Phelps, manager of The Royal Hotel at Gympie
Lucas Patchett, Co-founder of charity mobile laundry service, Orange Sky Laundry
Matthew Bass, Senior meteorologist Bureau of Meteorology forecaster
Mick Curran, Gympie Mayor
Mike Wilkins, Insurance Australia Group Ltd (IAG) MD and CEO
Mike Sopinski of RACQ Insurance, Queensland's second largest home insurer,
Mike Condon, QLD Police Assistant Commissioner
Nikki Chambers, Hazard Scientist at risk modeller RMS
Margaret Strelow, Rockhampton Mayor
Michael Shepherd, Asbestos Industry Association
Peter Jeffrey, State Emergency Services Assistant Commissioner
Peter Peirano, Piranha Insurance Brokers in Rockhampton
Phillip Wilkie, farmer in Jambin
Rob Whelan, ICA - Insurance Council CEO
Ron Carige, Banana Shire Mayor
Sam Campbell, BOM spokesperson
Steve Griffin, The Queensland Building and Construction Commissioner
Steve Gollschewski, QLD state disaster coordinator
Shannon Fentiman, Communities Minister
Tony Abbott, prime minister
Warren Young, Chief lifeguard at Gold Coast beaches

***Table AB-6**: Context of flood in WA (2017)*

Flood in Perth area (2017) – WA, Au
Newspaper online article
Beattie, A. (2017, 11/02/2017). Flood warnings and wild weather as storm lashes WA's south. Retrieved from https://www.watoday.com.au/national/western-australia/flood-warnings-and-wild-weather-as-storm-lashes-was-south-20170211-guar2f.html Bennet, M. (2017, 18/02/2017). Ravensthorpe cut off after WA floods wash away bridge into town. Retrieved from https://www.abc.net.au/news/2017-02-18/ravensthorpe-cut-off-as-floodwaters-claim-bridge-into-town/8282806 Collard, S. (2017, 14/02/2017). WA weather: Natural disaster declared over Swan Valley, other areas hit by flooding. Retrieved from https://www.abc.net.au/news/2017-02-13/premier-declares-natural-disaster-over-swan-valley-flood-areas/8265464 De Poloni, G. (2017, 15/02/2017). WA flood threat: Rivers swell in South West as water flows downriver. Retrieved from https://www.abc.net.au/news/2017-02-15/wa-flooding-threat-flows-downriver-to-south-west/8273292 Field, E. (2017, 14/06/2017). Dry start for WA croppers. The Weekly Times, p. 92. Powell, G. (2017, 11/02/2017). WA towns flooded, cut off as heavy rainfall hits state; more wet weather set for weekend. Retrieved from https://www.abc.net.au/news/2017-02-10/wa-towns-being-evacuated-amid-heavy-rainfall-flooding/8258178 Probert, O. (2017, 15/02/2017). Brookfield working on “extensive” flooding damage to East-West railway. Retrieved from https://www.bulkhandlingreview.com.au/brookfield-working-on-extensive-flooding-damage-to-east-west-railway/ Walsh, R. (2017, 14/02/2017). WA floods: Swan Valley wine region declared natural disaster zone. Retrieved from https://www.perthnow.com.au/news/wa/wa-floods-swan-valley-wine-region-declared-natural-disaster-zone-ng-d79db7a9977018a2d7570c911fbfe936
Audio-visual material—News
McHale, J., & Perpitch, N. (2017). Wet Perth: Overnight deluge: Perth, too, had its share of rain. Perth, WA: Seven News. Usher, M. (2017). WA flood emergency: There's a weather emergency of a different kind across the country. Sudney,NSW: Seven News.
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Barnett, H. C. (2017). Joint media statement - Disaster assistance for flood affected communities in Western Australia [Press release]. Retrieved from https://www.mediastatements.wa.gov.au/Pages/Barnett/2017/02/Joint-media-statement-Disaster-assistance-for-flood-affected-communities-in-Western-Australia.aspx BOM. (2017). Special Climate Statement 60—heavy rainfall and flooding in southwest Western Australia [Press release]. Retrieved from http://www.bom.gov.au/climate/current/statements/scs60.pdf BOM. (2017). Western Australia in February 2017: Wet with mild daytime temperatures. Retrieved from Melbourne, VIC: http://www.bom.gov.au/climate/current/month/wa/archive/201702.summary.shtml BoM. (2017). Monthly Weather Review Australia. Retrieved from Melbourne, VIC: http://www.bom.gov.au/climate/mwr/aus/mwr-aus-201703.pdf BOM (Cartographer). (2017). Flood watch areas. Retrieved from http://www.bom.gov.au/water/floods/floodWarningServices.shtml DFES. (2017). DFES urges caution after widespread flooding [Press release]. Retrieved from https://www.dfes.wa.gov.au/mediareleases/Pages/MediaRelease.aspx?ItemId=798 DFES. (2017). 2016/17 Wandrra eligible disaster proclamation notification - Flooding in Western Australia (January and February 2017) AGRN743. Perth, WA: Government of Western Australia,

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Interviews included in the secondary data
Andrew Duffield, The regional manager for Main Roads WA, Colby Quirk, a senior winemaker at Sitella vineyard in the Swan Valley, Colin Barnett, WA Premier, David Hooper, Business owner, Perth, Darryl Trease, Grape Growers Association of WA president, Dean Roberts, Main Roads spokesman, Eric Lembo, River Bank Estate owner in Swan valley, Gordon Davidson, Dumbleyung Shire president, Graham Swift, DFES Assistant Commissioner Country Operation, Grant Brinklow, Sandalford Wines chief executive in Swan valley, Ian Fitzgerald, Ravensthorpe shire CEO, Laura and Derek Pearse, owners of the Upper Reach Winery in Swan valley, Lily Prosser, cafe business owner in Ravensthorpe, Mark Beasley, Manager Real Time Traffic Operations at Main Roads WA, Mark McGowan, WA Labor leader, Michael Keenan, Minister for Justice, Neil Bennett, BOM representative, OEM district advisors, Rick Wilson, The federal government member, Sharon Winter, Event organiser of annual country music festival at Boyup Brook, Stephen Duggan, BoM Flood Forecasting and Warning Manager WA, Steve Joske, WA State Recovery Coordinator, Wayne Green, Superintendent - The Department of Fire and Emergency Services, Wayne Gregson, Fire and Emergency Services Commissioner, Yvette Wheatcroft, Gnowangerup shire spokeswoman.

***Table AB-7**: Context of Cyclone Debbie (2017)*

Cyclone Debbie (2017) – QLD, Australia
Newspaper online article
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1,200 members of impacted communities in the NSW,
Annastacia Palaszczuk, Queensland Premier and Minister for the Arts,
Anthony Lynham, Queensland State Development Minister,
Becky Gollings, NSW SES spokeswoman,
Ben Martin, mango farmer from affected region,
Bruce Gunn, BOM regional director,
Bruce Gunn, BOM QLD state manager,
Campbell Fuller, General Manager Communications & Media Relations in the ICA,
Catherine Cookson, Industry Recovery and Resilience Officer (IRRO) in Bowen,
Craig Burke, BOM senior forecaster,
Curtis Pitt, The treasurer of the Queensland state government

Dr Jeff Sabburg, BOM climatologist,
Dr Stephen Robinson, Reverend at Uniting Church's national disaster recovery officer,
Frans Knox, BHP Billiton and Mitsubishi Alliance asset president,
Gladys Berejiklian, NSW Premier,
Glen Clarke, cane crop farmer at Proserpine,
Greg Plath, Mackay canegrower,
Iain Mackenzie, Inspector-General Emergency Management,
Ian Stewart, Queensland Police Commissioner,
Jake Klein, Evolution executive chairman,
Jenny Hill, Townsville Major,
John Bates, director of The Australian Institute for Disaster Resilience,
John Collins, the Whitsunday deputy mayor and Proserpine's only butcher,
Justine Cox, Lismore-based telephone counsellor,
Katarina Carroll, Commissioner of Queensland Fire and Emergency Services,
Lene Knudsen, Climate and Resilience Coordinator,
Luke Smith, Logan Mayor,
Malcolm Turnbull, Prime Minister,
Mark Morrow, NSW SES Acting Deputy Commissioner,
Mark Ryan, Minister for Police, Fire and Emergency Services and Minister for Corrective Services,
Peter Cowan, Aurizon Vice president,
Richard Thornton, head of the Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC),
Rick Threlfall, senior meteorologist BOM,
Rob Stork, Energex spokesman,
Rod Chetwynd, Fire & Rescue NSW New England Northern West Duty Commander Inspector,
Ron Petterson, the chairman of Police Citizen Youth Club and the Whitsundays Suicide Prevention Network,
Ross Henry, QLD Farmers Federation project manager,
Scott Turner, Lismore Council's emergency management officer,
Steve Gollschewski, Police Deputy Commissioner,
Sue Pritchard, SES spokeswoman,
Russell Zimmerman, Australian Retailers Association executive director,
Tom Tate , Gold Coast Mayor,
Tony Mahar, National Farmers' Federation chief executive.

***Table AB-8**: Context of Pacific Ocean typhoon season (2013)*

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***Table AB-9**: Context of Typhoon Soudelor (2015)*

Typhoon Soudelor (2015) – Taiwan
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Interviews included in the secondary data

Caroline Tsai – Taiwan resident, Chris Johnson, FM Global, Executive Vice President, Dave Petley, landslide expert at the University of East Anglia Taiwan, Local Fujian government representatives, Officials of Yilan county, Spokesman for Taoyuan fire agency.
Additional material
More than 200 time labelled and location tagged photographs examined.

***Table AB-10**: Context of Hailstorm in Huntingwood (2015)*

Hailstorm in Huntingwood (2015) – QLD, Au
Newspaper online article
AAP. (2015, 25/04/2015). Sydney hit by hail, flash floods, as storm-affected areas warned to expect more. Retrieved from https://www.theguardian.com/australia-news/2015/apr/25/sydney-hit-by-hail-and-flash-floods-as-storm-affected-areas-warned-to-expect-more ABC. (2017, 20/02/2017). Sydney storms: 12,000 insurance claims lodged from hailstorm, $31 million in damages. Retrieved from https://www.abc.net.au/news/2017-02-19/insurance-already-flooded-with-sydney-storm-claims-from-hail/8284246 Advocate, B. (2015, 15/05/2015). Huntingwood still picking up the pieces three weeks after hailstorm tore through western Sydney. News. Retrieved from https://www.dailytelegraph.com.au/newslocal/west/huntingwood-still-picking-up-the-pieces-three-weeks-after-hail-storm-tore-through-western-sydney/story-fngr8i5s-1227360021220 Cummins, C. (2015, 28/04/2015). Storm damage: costs could reach $80m, short term industrial leases in demand. Retrieved from https://www.smh.com.au/business/companies/storm-damage-costs-could-reach-80m-short-term-industrial-leases-in-demand-20150428-1mv8cs.html Cummins, C. (2015, 02/06/2015). Storm hits industrial property with $302m bill. Retrieved from https://www.smh.com.au/business/companies/storm-hits-industrial-property-with-302m-bill-20150602-ghezbd.html Lambert, K. I. (2015). Extreme Huntingwood hailstorm, multiple major structural collapse and distribution warehouse fire 10th alarm response, 25 April 215. *Fire & Rescue News NSW*, 38-50. Neems, M. (2015, 27/04/2015). Hailstorm weighs on Metcash. Business Spectator. Retrieved from https://www.theaustralian.com.au/business/business-spectator/news-story/hailstorm-weighs-on-metcash/62cf55f824e2b78ec794c43c90bbe9b0 O'Brien, J., & Shelley, N. (2015, 26/04/2015). Sydney hail storm: Severe thunderstorm warnings cancelled for NSW, ACT after city blanketed with hail. Retrieved from https://www.abc.net.au/news/2015-04-25/severe-storm-warning-issued-for-parts-of-nsw-and-act/6421688 Oxford, J. (2015, 28/04/2015). Anzac Day hailstorm causes six Huntingwood factories to collapse and millions of dollars worth of damage. Retrieved from https://www.dailytelegraph.com.au/newslocal/anzac-day-hailstorm-causes-six-huntingwood-factories-to-collapse-and-millions-of-dollars-worth-of-damage/news-story/3c0ded934c01ce2734d473615ad7a22e
Audio-visual material—News
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AA. (2015, 27/04/2019). Metcash Contingency plans ensure NSW products keep moving. Company News Summary | 27 Apr 2015. Retrieved from https://www.morningstar.com.au/Stocks/SignalGNewsPrint/20150427/329285 ICA. (2015). Sydney Anzac Day hailstorm claims pass $60m [Press release]. Retrieved from https://www.insurancecouncil.com.au/assets/media_release/2015/REISSUING%20-%20010515%20Anzac%20Day%20hailstorm%20declared%20a%20catastrophe%20-%20CORRECTS%20STORM%20DATA.pdf Metcash. (2016). Annual Report 2016. Retrieved from Sydney, NSW

Watson, G. (2015). Metcash - FY16 Half Year Results. Retrieved from Sydney, NSW: www.metcash.com Woodhill, S. (2015). Press Release: Metcash contingency plans ensure NSW products keep moving [Press release]. Retrieved from https://mars-metcdn-com.global.ssl.fastly.net/content/uploads/sites/101/2017/04/18105125/2015-April-27-Contingency-plans-ensure-NSW-products-keep-moving.pdf
Interviews included in the secondary data
Darren Curry, the divisional director for industrial sales and leasing at Savills Australia, Gary Fry, Blacktown SES controller, Greg Watson, Company Secretary at Metcash, Ian Morrice, Metcash CEO, Kernin Lambert, Fire and Rescue NSW duty commander for western Sydney Inspector, Michael Chesworth, the SES, Moshe Greengarten, industrial executive at Savills, Paul Johnston, Superintendent Fire and Rescue NSW, Rob Whelan, The Insurance Council of Australia (ICA) CEO, Spokesman for Goodman Group's Bungarribee Industrial Estate, Transport Management Centre spokesman, Woodhill Stephen, Group General Manager Corporate Affairs at Metcash.

***Table AB-11**: Context of Millennium drought (2000–2010) and flood (2010–2011)*

Millennium drought (2000-2010) and flood (2010) – QLD, Au
Newspaper online article
AAP. (2008, 10/02/2008). More of NSW moves out of drought. The Sydney Morning Herald. Retrieved from https://www.smh.com.au/national/more-of-nsw-moves-out-of-drought-20080210-gds0ec.html Cyclone Yasi. (2011, 29/06/2019). Retrieved from https://en.wikipedia.org/wiki/Cyclone_Yasi Cyclone Yasi: What happened. (2016, 03/03/2016). Retrieved from https://www.abc.net.au/news/2016-02-03/cyclone-yasi-what-happened-in-2011/7067086 Ferguson, J., & Barry, E. (2011, 05/02/2011). Severe storms, flash floods hit Melbourne and parts of Victoria. News. Retrieved from https://www.heraldsun.com.au/ipad/storm-to-move-south-and-soak-victoria/news-story/a1b6356e643191516b47ae87f3139edd?sv=6a2520feb06c01b5bcf04a0219f711a2 Freund, M., Henley, B., Allen, K., & Baker, P. (2018, 02/05/2018). Recent Australian droughts may be the worst in 800 years. Retrieved from http://theconversation.com/recent-australian-droughts-may-be-the-worst-in-800-years-94292 Macey, R. (2008, 04/01/2008). This drought may never break. The Sydney Morning Herald. Retrieved from https://www.smh.com.au/environment/this-drought-may-never-break-20080104-gdrvg6.html Murray, L. (2011, 01/12/2015). Australia floods of 2010–11. Retrieved from https://www.britannica.com/event/Australia-floods-of-2010-2011 Water and Cotton Fact Sheet (2007, 13/02/2007). Retrieved from https://cottonaustralia.com.au/news/DisplayNews.aspx?id=365&NewsCategoryID=1
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BOM. (2011). Flood summary for the Nogoa River at Emerald – December 2010 and January 2011. Retrieved from Melbourne, VIC: http://www.bom.gov.au/qld/flood/fld_reports/emerald_fact_sheet_2011.pdf
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Wachinger, G., Renn, O., Begg, C., & Kuhlicke, C. (2013). The risk perception paradox-implications for governance and communication of natural hazards. *Risk Analysis: An International Journal*, 33(6), 1049-1065.

Interviews included in the secondary data

Anna Blight, QLD prime minister at the time,
CEO of Mildura Development Corporation,
Dr David Jones, Head of climate analysis, BOM,
Dr Luke Mosley, Environmental Protection Agency spokesperson,
Ian Macdonald, Primary Industries Minister of NSW,
Julia Gillard, Prime Minister of Australia at the time,
Morris Iemma, NSW Premier,
Rob Webb, BOM spokesperson,
Saul Eslake, Chief Economist with ANZ bank,
Terry Ryan, forecaster at Weather bureau.

***Table AB-12**: Context of Eyjafjallajökull eruption (2010)*

Eyjafjallajökull eruption (2010) – Iceland, EU
Newspaper online article
Budd, L., Griggs, S., Howarth, D., & Ison, S. (2011). A fiasco of volcanic proportions? Eyjafjallajökull and the closure of European airspace. *Mobilities*, 6(1), 31. doi:10.1080/17450101.2011.532650 Business News: Ash disrupts deliveries to British shops. (2010, 17/04/2010). Retrieved from https://upi.com/3247973 Evans, J. (2011, 06 Feb 2011). Weathering the Storm: How companies can protect themselves in an uncertain world, *Wallstreet Journal*. Iceland volcano cloud: The economic impact. (2010, 20/04/2010). Retrieved from http://news.bbc.co.uk/2/hi/8629623.stm Jensen, O. (2011). Emotional eruptions, volcanic activity and global mobilities - A field account from a European in the US during the eruption of Eyjafjallajökull. *Mobilities*, 6(1), 67. doi:10.1080/17450101.2011.532653 Maidment, P. (2010, 17/05/2010). Ash In The Supply Chain. Retrieved from https://www.forbes.com/sites/davos/2010/05/17/ash-in-the-supply-chain/#73f5ef77edaa Tweed, F. S. (2012). 'Now that the dust has settled...' the impacts of Icelandic volcanic eruptions. *Geology Today*, 28(6), 217-223. doi:10.1111/j.1365-2451.2012.00854.x Volcanic ash: Flight chaos to continue into weekend. (2010, 16/04/2010). Retrieved from http://news.bbc.co.uk/2/hi/europe/8623534.stm Waihenya, W. (2010, 21/04/2010). How Iceland's volcano sears Kenya's crops. Retrieved from https://www.theguardian.com/commentisfree/2010/apr/20/iceland-volcano-kenya-flight Wearden, G. (2010, 21/10/2010). Nissan and BMW car production hit by volcano disruption. Retrieved from https://www.theguardian.com/business/blog/2010/apr/20/nissan-suspends-car-production-volcano-ash-cloud
Audio-visual material—News
Carter, S. p., Mortimore, M., Leckey, B., Pertwee, S., & Pioneer, P. (2010). The volcano that stopped the world: ABC Television. Pertwee, S. (2010). The Volcano That Stopped The World [video]: Informit, Melbourne (Vic.).
Published research papers
Alemanno, A. (2010). The European regulatory response to the volcanic ash crisis between fragmentation and integration. *European Journal of Risk Regulation : EJRR*, 1(2), 101-106. Alexander, D. (2013). Volcanic ash in the atmosphere and risks for civil aviation: A study in European crisis management. *International Journal of Disaster Risk Science*, 4(1), 9-19. doi:10.1007/s13753-013-0003-0 Bird, D., Gisladottir, G., & Dominey-Howes, D. (2011). Different communities, different perspectives: issues affecting residents' response to a volcanic eruption in southern Iceland. *Bull. Volcanol.*, 73(9), 1209-1227. doi:10.1007/s00445-011-0464-1 Donovan, A., & Oppenheimer, C. (2012). Governing the lithosphere: Insights from Eyjafjallajökull concerning the role of scientists in supporting decision-making on active volcanoes. *Journal of Geophysical Research. Solid Earth*, 117(B3). doi:10.1029/2011JB009080 Lund, K. A., & Benediktsson, K. (2011). Inhabiting a risky earth: The Eyjafjallajökull eruption in 2010 and its impacts. *Anthropology Today*, 27(1), 6-9. doi:10.1111/j.1467-8322.2011.00781.x Parker, C. (2015). Complex negative events and the diffusion of crisis: Lessons from the 2010 and 2011 Icelandic volcanic ash cloud events. *Geografiska Annaler: Series A, Physical Geography*, 97(1), 97-108. doi:10.1111/geoa.12078

Ruiz, C., & Hernandez, B. (2014). Emotions and coping strategies during an episode of volcanic activity and their relations to place attachment. *Journal of Environmental Psychology*, 38, 279-287. doi:10.1016/j.jenvp.2014.03.008

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Skorokhod, A., Elansky, N., Safronov, A., Eremina, I., Pankratova, N., & Chubarova, N. (2016). The impact of the April 2010 Eyjafjallajökull eruption on the atmosphere composition in Moscow. *Volcanology and Seismology*, 10(4), 263-274. doi:10.1134/S0742046316040059

Stevenson, J. A., Loughlin, S., Rae, C., Thordarson, T., Milodowski, A. E., Gilbert, J. S., . . . Cassidy, M. (2012). Distal deposition of tephra from the Eyjafjallajökull 2010 summit eruption. *Journal of Geophysical Research. Solid Earth*, 117(B9). doi:10.1029/2011JB008904

Wachinger, G., Renn, O., Begg, C., & Kuhlicke, C. (2013). The risk perception paradox-implications for governance and communication of natural hazards. *Risk Analysis: An International Journal*, 33(6), 1049-1065.

Interviews included in the secondary data

BMS Group spokesperson,
David Noble, chief executive at Chartered Institute of Purchasing and Supply,
Gordon Brown, The Prime Minister of Great Britain,
Grant Liddell, retail director at Uniserve Group,
Hugo Crawley, chairman of insurance broker,
James Crask, senior manager at PricewaterhouseCoopers' risk and business continuity team,
Mathias Schmidt, BMW spokesman,
Nissan spokesman,
Thomas Hess, chief economist at Swiss Re,
Vanessa Rossi, Chatham House senior economic fellow,
Vincent West, head of UK business continuity practice at risk manager AON.

***Table AB-13**: Context of Tohoku earthquake and tsunami (2011)*

Tohoku earthquake and tsunami (2011)—Japan
Newspaper online article
AP. (2011, 11/05/2011). Toyota profit slides on Japan earthquake disruption. *Business*. Retrieved from https://www.theguardian.com/business/2011/may/11/toyota-profit-hit-by-japan-earthquake Brown, E. (2011, 13/03/2011). 9.0 Japan earthquake shifted Earth on its axis. Retrieved from http://articles.latimes.com/2011/mar/13/science/la-sci-japan-quake-science-20110313 Buerk, R. (2012, 29/02/2012). Japan's damaged Fukushima nuclear plant one year on. Retrieved from https://www.bbc.com/news/world-asia-17192215 Carty, S. S., & Kurtenbach, E. (2011, 29/03/2011). Tohoku disaster may bring automakers to their knees. Business. Retrieved from https://www.japantimes.co.jp/news/2011/03/29/business/tohoku-disaster-may-bring-automakers-to-their-knees/#.XRmxsugza71 Edgerton, J. (2012). How the Japanese tsunami changed the auto industry. MoneyWatch. Retrieved from https://www.cbsnews.com/news/how-the-japanese-tsunami-changed-the-auto-industry/ Fackler, M. (2011, 12/03/2011). Powerful Quake and Tsunami Devastate Northern Japan. The New York Times. Retrieved from https://www.nytimes.com/2011/03/12/world/asia/12japan.html Hall, A. (2011, 23/03/2011). Japan disaster's 'ripple effect' on Australian auto industry. Retrieved from https://www.abc.net.au/news/2011-03-23/japan-disasters-ripple-effect-on-australian-auto/2646216 Kyodo. (2015, 07/07/2015). State-of-the-art Himawari-8 weather satellite goes active, online. The Japan Times. Retrieved from https://www.japantimes.co.jp/news/2015/07/07/national/state-art-himawari-8-weather-satellite-goes-active/#.XD1RA1wza70 Onishi, N., Fackler, M., & Suzuki, K. (2011, 13/06/2011). In Nuclear Crisis, Crippling Mistrust. The New York Times. Retrieved from https://www.nytimes.com/2011/06/13/world/asia/13japan.html Rafferty, J. P., & Kenneth, P. (2018, 15/10/2018). Japan Earthquake and tsunami of 2011. Retrieved from https://www.britannica.com/event/Japan-earthquake-and-tsunami-of-2011 Randewich, N., & MacMilan, R. (2011, 23/03/2011). HP, Dell assess Japan earthquake impact. Retrieved from https://www.reuters.com/article/us-hp-earthquake/hp-dell-assess-japan-earthquake-impact-idUSTRE72L52Z20110322 Roser, C. (2018, 27/02/2018). The Grand Tour of Japanese Automotive – Overview and Toyota. Retrieved from https://www.allaboutlean.com/grand-tour-overview-and-toyota/ Sample, I. (2011, 12/03/2011). Japan earthquake and tsunami: What happened and why. Retrieved from https://www.theguardian.com/world/2011/mar/11/japan-earthquake-tsunami-questions-answers Tajitsu, N. (2016, 30/03/2016). Five years after Japan quake, rewiring of auto supply chain hits limits. Retrieved from https://www.reuters.com/article/us-japan-quake-supplychain-idUSKCN0WW09N Uranaka, T., & Kwon, K. J. (2011, 13/03/2011). Japan fights to avert nuclear meltdown after quake. Retrieved from https://www.reuters.com/article/us-japan-quake/japan-fights-to-avert-nuclear-meltdown-after-quake-idUSTRE72A0SS20110313
Audio-visual material—News
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Dunbar, P., McCullough, H., Mungov, G., Varner, J., & Stroker, K. (2011). 2011 Tohoku earthquake and tsunami data available from the National Oceanic and Atmospheric Administration/National Geophysical Data Center AU - Dunbar, Paula. Geomatics, Natural Hazards and Risk, 2(4), 305-323. doi:10.1080/19475705.2011.632443

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Gulati, R., Casto, C., & Krontiris, C. (2014). How the Other Fukushima Plant Survived. *Harvard Business Review*, 92(7/8), 111-115.
Raby, A., Macabuag, J., Pomonis, A., Wilkinson, S., & Rossetto, T. (2015). Implications of the 2011 Great East Japan Tsunami on sea defence design. *International Journal of Disaster Risk Reduction*, 14, 332-346. doi:https://doi.org/10.1016/j.ijdrr.2015.08.009
Sugano, T., Nozu, A., Kohama, E., Shimosako, K.-i., & Kikuchi, Y. (2014). Damage to coastal structures. *Soils and Foundations*, 54(4), 883-901. doi: 10.1016/j.sandf.2014.06.018
Zaré, M., & Afrouz, S. G. (2012). Crisis management of Tohoku; Japan earthquake and tsunami, 11 March 2011. *Iranian journal of public health*, 41(6), 12-20.

Interviews included in the secondary data

Barak Obama, President of USA,
Brian Johnson, an auto analyst with Barclays Capital,
Christopher Richter, an industry analyst at CLSA Asia Capital Markets,
Emily So, an engineer with the United States Geological Survey,
Evan Stents, Lawyer and automotive industry analyst,
Fortunes O'Neal, general manager at Park Cities Ford in Dallas,
Hillary Clinton, US Secretary of State,
Hiroaki Mochida, an analyst at Marusan Securities,
Kan Naoto, Prime Minister of Japan (2010-2011),
Kiyoshi Kurokawa, Chairman of Health and Global Policy Institute,
Koji Endo, managing director at Advanced Research Japan in Tokyo,
Lucy Jones, chief scientist for the Multi-Hazards project,
Mark Hibbs, Nuclear expert of the Carnegie Endowment,
Mark Higgins, the public relations manager for Honda Australia,
Masaru Kudo, a soldier dispatched to Rikuzentakata,
Michala Marcussen, head of global economics at Société Générale,
Nils Oldenburg, head of global pigments production in German drugs and chemicals maker Merck KGaA (MRCG.DE),
Noda Yoshihiko, Prime Minister of Japan (2011-2012),
Norihito Umino, Professor at National Astronomical Observatory of Japan,
Paul Newton, analyst with IHS Automotive,
Richard Gross, a geophysicist at the Jet Propulsion Laboratory,
Richard Reilly, the chief executive of the Federation of Automotive Products Manufacturers,
Steve MacIver, public relations manager at Mazda,
Spokesman for the American Seventh Fleet in Japan,
Spokesman at Japan's Renesas Electronics Corp,

Susan Hough, seismologist at U.S. Geological Survey,
Takahiro Fujimoto, Professor and executive director at Tokyo University's Manufacturing Management Research Center,
Tim Coulling, analyst at Canalys PC,
Tom Heaton, seismological engineer at Caltech,
Vasily V. Titov, director of the National Oceanic and Atmospheric Administration's Center,
William M. Tsutsui, professor of Japanese business and economic history at Southern Methodist University in Dallas,
Yoshihiro Nakane, president at TRW Automotive Japan.
Yukio Edano, Chief Cabinet Secretary of Japan.

APPENDIX C: TABLED RESULTS FROM CROSS-CASE ANALYSIS

***Table AC-1**: SCI coded for types and orientations in different SCRES building stages in all SCs examined*

SCRES stage	SCI orientation	SCI type	SC coded for specific SCI type and orientation, within specific SCRES stage																					
			Q1	Q2	T1	T2	T3	T4	HS1	L1	M1	M2	M3	M4	W1	D1	D2	PO1	TS1	A1	A2	AM1	VE1	ET1
Stage 1 - Preparation	Internal DAO or interviewee	Informational				☑			☑		☑	☑	☑		☑									
		Operational							☑			☑	☑		☑									
		Relational			☑																			
	Supplier	Informational																						
		Operational	☑																					
		Relational	☑														☑							
	Buyer	Informational							☑							☑								
		Operational														☑								
		Relational															☑							
	T&L & DAO	Informational							☑															
		Operational																						
		Relational															☑							
	Government	Informational								☑														
		Operational																						
		Relational								☑														
	Community	Informational																						
		Operational																						
		Relational																						

SCRES stage	SCI orientation	SCI type	Q1	Q2	T1	T2	T3	T4	HS1	L1	M1	M2	M3	M4	W1	D1	D2	PO1	TS1	A1	A2	AM1	VE1	ET1
Stage 2 – Initial Response	Internal	Informational	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑		☑	☑
		Operational		☑					☑	☑	☑	☑	☑	☑	☑	☑	☑			☑	☑			☑
		Relational			☑	☑		☑	☑	☑	☑			☑	☑		☑							
	Supplier	Informational				☑			☑	☑	☑							☑						
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	Buyer	Informational			☑	☑			☑	☑	☑								☑			☑		☑
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	Buyer's buyer	Informational																						
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	T&L & DAO	Informational		☑			☑		☑	☑			☑											
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	Government	Informational	☑	☑	☑				☑		☑		☑	☑	☑	☑	☑		☑	☑	☑	☑	☑	☑
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		Relational																						
	Community	Informational		☑	☑																			
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SCRES stage	SCI orientation	SCI type	Q1	Q2	T1	T2	T3	T4	HS1	L1	M1	M2	M3	M4	W1	D1	D2	PO1	TS1	A1	A2	AM1	VE1	ET1
stage 3 – Reconstruction	Internal or interviewee	Informational			☑	☑	☑			☑	☑		☑	☑		☑	☑	☑	☑	☑	☑	☑	☑	☑
		Operational			☑	☑	☑			☑	☑	☑	☑	☑		☑	☑	☑	☑	☑	☑	☑	☑	☑
		Relational			☑	☑				☑	☑	☑				☑	☑	☑		☑				
	Supplier	Informational			☑	☑											☑			☑				
		Operational															☑			☑				
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	Buyer	Informational			☑	☑				☑	☑	☑		☑		☑			☑	☑	☑	☑		☑
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	Buyer's buyer	Informational																						
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	T&L & DAO	Informational					☑			☑		☑	☑											
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	T&L and Dao's supplier	Informational				☑																		
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SCRES stage	SCI orientation	SCI type	Q1	Q2	T1	T2	T3	T4	HS1	L1	M1	M2	M3	M4	W1	D1	D2	PO1	TS1	A1	A2	AM1	VE1	ET1
Stage 4 – Recovery	Internal or interviewee	Informational	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑		☑	
		Operational	☑	☑	☑				☑	☑	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑		☑	
		Relational	☑	☑	☑				☑	☑	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑		☑	
	Supplier	Informational	☑		☑				☑		☑		☑				☑	☑		☑		☑		
		Operational			☑				☑		☑						☑	☑		☑		☑		
		Relational	☑		☑				☑			☑			☑		☑	☑		☑		☑		
	Buyer	Informational	☑		☑			☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
		Operational						☑							☑	☑		☑	☑	☑		☑	☑	☑
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	Buyer's buyer	Informational			☑														☑		☑			
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	T&L & DAO	Informational					☑		☑	☑		☑	☑											
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	T&L and Dao's supplier	Informational		☑										☑										
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SCRES stage	SCI orientation	SCI type	Q1	Q2	T1	T2	T3	T4	HS1	L1	M1	M2	M3	M4	W1	D1	D2	PO1	TS1	A1	A2	AM1	VE1	ET1
Stage 5 - Mitigation	Internal or interviewee	Informational		☑		☑				☑	☑	☑	☑	☑	☑	☑								
		Operational									☑	☑	☑		☑									
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	Supplier	Informational																						
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Note: SCI described in different SCs as supportive for SCRES, within different SCRES stage (☑ = building SCI to utilise it in other stages, ☑ = lack of SCI to support SCRES described, ☑ = utilised in the marked stage)

***Table AC-2**: Direct statements samples coded for different SCI types and orientations in each SCRES building stage*

SCRES stage	SCI orientation	SCI type	number of SCs	sample statements
1 - Preparation	Internal DAO	informational	5	*"You need to know those plans; people need to be aware of them and rehearsed in them…", M3* *"It's taking a more pragmatic forward-looking view to say: "Okay, if these storms and events are becoming more frequent and more severe, how do we actually structure our organisation to be more responsive, adaptive to meet the needs of the environment that we're in?" Communicate in the organisation, how to address it, how to improve it.", T2*
		operational	4	*"Communicate them [plans] in company and practice them!" W1* *"You'd better sure that you've got them in place and that they are utilised, tested... that they work." HS1*
		relational	1	*"… you have to be able to be honest and humble during your wins, so when you do get good results, you've gotta also understand that a bad weather event is just across the corner", and "They [employees] understand that you do the best you can during good times because humble times are not far away.".T1*
	Supplier	operational	1	*"If you go to consignment stock, basically you're saying ... You're building up a much higher level of trust between a supplier and yourself. You're doing two things. You're saying, "Look, I like you as a supplier so much that I'm quite happy for you to dump, fill up our capacity," and then the arrangement is that whatever [in terms of payment] ... The supplier likes it because it's saying, well, okay, so we've got a long-term contract here and that's how I usually ran it… we've got benefits in fostering trust in the relationship with suppliers*.", Q1
		relational	1	
	Buyer	informational	1	*"We have a brilliant customer on board as a new customer or a customer contract review, or in fact a business review... When we onboard customers, we go through disaster management planning. We have our internal checklist of what we look for in sites, it's what a lot of customers have themselves…" D1*
		operational	1	*"I think ourselves and our customers have moved on where we can do something together about it…", D1*
		relational	1	*"…build those strong partnerships … built on strong … setting the strong customer expectations from the outset.", D2*
	T&L & DAO	informational	1	"*... when you negotiate your sea freight rates, okay, you have to ... you have a backup lane. So, you have a lane that is instead of moving through the east coast of America you move product through the west coast of America. Right. You can also move product from the United States ... east coast of America to ... Europe. And then from Europe you can get a connection to Australia. So, there's two backup lanes.",* HS1
		relational	1	*"I always talk about, … build those strong partnerships with whoever you use as providers…"D1*

SCRES stage	SCI orientation	SCI type	number of SCs	sample statements
1 - Preparation	Government	informational	1	*"…if you have a business or an interest in a business, you want to get on board with those, then register on the BOM website for alerts, and then every day through the season you will receive an email alert with basically an outlook.*", L1
		relational	2	*"It's the relationship beforehand. It's a waste of time trying to build a relationship when it's thunder and lightning, you've got to spend the time building a relationship when times are good... You've got the relationship piece with two key stakeholders, being Main Roads WA and the port authority, such that you can coordinate what you're trying to achieve, such that you get an outcome more quickly", L1*

SCRES stage	SCI orientation	SCI type	number of SCs	sample statements
2 – Initial Response	Internal in DAO or interviewee's company	informational	20	*"We look at our trucks that are on the road, where they are, where they're going, they let us know, we make decisions…executive leadership team meets on a weekly base, … and they have touch points on what's happening on current contracts as far as exceptions. They meet during crisis, more often." D1*
		operational	13	*"…we had our team doing it together", M4* *"So, this is teamwork. Obviously, I can't say that only one department is affected because of this extreme weather condition. Basically everything, every department is affected.", ET1*
		relational	9	*"…we want to keep our people in, and we want to keep our people in who are safe, who are fed, who are watered. So, we're trying to get our people safe, they need to be alright…", L1*
	Supplier	informational	6	*"So, in that circumstance, whenever we have issues, we are able to pick up the phone and say, "Supplier, we're having an issue." Or slow down these PO's [purchase order]…", D2*
		operational	4	*"And we had relationships with our suppliers where they'd given out POs well in advance. And, for our bigger suppliers, they do make and hold the product there locally, and then we draw on it as we need it…", D2*
		relational	4	*"…the suppliers would still bend over backwards to meet those requirements...", PO1*
	Buyer	informational	8	*"they will just say ... normally when it's a warning coming up, they will tell us, "Okay, they're gonna shut down for a few days because of extreme weather or the typhoon." Then, through that communication, then we know that okay, maybe this supply will be disrupted due to the typhoon.", TS1*
	T&L & DAO	informational	5	*" So, we'd be talking to transport companies and our shift operators to say, "Right, when this hit [flood reaches stores], this is your priority. Make sure we get it on the road asap.".Q2*
		operational	4	*" … it would be working through sitting down with transport companies and working out how we could get through or around to get into those towns.",Q2*
		relational	2	*"…Obviously need to have very good relationships with your [T&L] suppliers…", HS1*
	Government	informational	16	*"We spoke with public organisation about road openings and rail opening, we tracked water withdrawal", Q1*
		operational	3	*"Liaising with the bureau of meteorology to determine which of the areas that we needed to focus on putting controls in place to ensure people were safe. We were basically having daily meetings.", M4*
	Community	informational	2	*Interviewee described informing community where to get necessities and making sure necessary items are available for community members: "So you'd be trying to get a load of bottled water, candles, matches, lighters… lighting and drinking water were the main things you were trying to get through. You need to make sure local families have that. They need it.", Q2*
		relational	1	

SCRES stage	SCI orientation	SCI type	number of SCs	sample statements
3 –Reconstruction	Internal in DAO or interviewee ’s company	informational	16	*“speaking to them, telling them that the organisation is doing whatever they can to assist them “T1* *We had a general management team come to site and they set up themselves into the board room of the site at the time, so they had a base set up with everything that was occurring. They were aware of, they were involved. They put plans together.”A2*
		operational	17	“*I know they had a lot of information coming back and forward between different teams, they coordinated those renovations and recovery among themselves quite effectively.”, T3* *“They [employees] got in and it really helped us to get things going quickly … they just get in whatever we need to do, they just did it and worked with us.”, A2* *“…teams of Metcash staff had worked hard over the weekend to put arrangements in place to minimise the impact on supplied retailers and their customers”, A1*
		relational	9	*“…leading by example was what motivates or also brings out the best in people. So that's my style. I don't ask people to do anything I wouldn't do myself.”,* HS1 “*I must say our [company name] employees are very positive in their approach to things. They take some ownership of what they look after for our business…. They were very willing and happy to work ….”*, A2 *“ It comes back to the values of an organisation, the values of the individuals. I think the human element of people during crisis tends to shine through irrespective of where and who and how...”,T2*
	Supplier	informational	4	*“I think communication is the key with everyone. The sooner you communicate with relevant stakeholders, the better it is and tell me the ability to quantify as quickly as possible with about as much accuracy as possible ... whether that is losses, whether that is yield, whether that is anything*”, T1 “*So, in that circumstance, whenever we have issues, we are able to pick up the phone and say, "Supplier, we're having an issue." Or slow down these PO's [purchase order]. We've not had an instance where that hasn't happened…*”, D2
		operational	2	*“And we had relationships with our suppliers where they'd given out POs well in advance. And, for our bigger suppliers, they do make and hold the product there locally, and then we draw on it as we need it…”, D2*
		relational	3	*“I'd call it just the relationship, the partnership that we have, and we do work really well together. So, whenever we say there's an issue here, whatever, they're very accommodating. So, we don't have ongoing issues. It's a very, very mutual strong relationship where they understand whenever there's problems, and we always, always work together to resolve the issue. We're a working partnership all the time.*”, D2 *“This is testimony to the strength of our relationships with our suppliers…” A1*

SCRES stage	SCI orientation	SCI type	number of SCs	sample statements
3 –Reconstruction	Buyer	informational	12	"*I think, at that point it really is just about keeping your customer base informed. Once they know there's a problem and you've been proactive and you're working with them, they know it's not something you did, they know it's not your fault, and they're not looking to blame you, they're just looking for you to be honest, open, and communicate what's going on with them.*"*AM1* *At the same time [with cleaning] there was a communication process to our customers because there would have been insurance requirements effects on their products because the insurance of the products owned by the customers...*", A2 "*We have alerted our retail customers to the issue and explained that whilst the continuity processes are implemented, there may be delays in delivering product*,"A1
		operational	3 + 1	*"We were very quick to get communication to them and help them to put together teams to assess the damage to their products and I guess their business, we worked together very closely to ensure there was very good cooperation from both sides.", A2* *"They [DAO] would put additional resources in when customers would demand something or say it is urgent...".VE1* *Interviewer: "Did they ever ask you for financial support during that times or for some other kind of support?" Interviewee: "No. They can try, but never get it!", TS1*
		relational	6 + 1	Interviewee A2 describes cooperation and communication as very close and honest with buyers "*I am humbled by the support that exists within the Metcash network and proud of our team's commitment to our customers and their businesses", A1* "…*if possible, or depending on the sensitivity of the issue, send supervisors from the company to check their situation of the supplier over there. How they are doing. Are they actually following the plan that they are updating every week, or not? So, by this supervision and exchanging the plan and getting updates on a weekly basis, you make sure that if contingency plan or reviving plan is happening, you are basically safe, and your product is safe*.", ET1

SCRES stage	SCI orientation	SCI type	number of SCs	sample statements
3 –Reconstruction	T&L & DAO	informational	4	*"we knew exactly what delivery order was going where, what would be impact to the business." M3* *""I know they had a lot of information coming back and forward between different teams, they coordinated those renovations and recovery among themselves…" T3 describing being kept informed by DAO*
		operational	3	*"… it was our plan for that transport piece, not their plan and my plan, it was one plan. For the stevedore, the landside stevedore, which is [T&L company name], again working with them to make sure that they were in line with our plans.", L1*
		relational	2	*"You've got the recovery plans in relation to getting people back into the area, so that's about booking out space with airlines… airline might be more likely to want to play ball, in terms of freeing up seats for you...", L1*
	T&L and DAO's supplier	informational	1	*"Whether you knew you could get a vehicle tomorrow or not… a lot of it was about communication, getting up and saying: "Yep, we've got ten vehicles stuck outside Brisbane that can't get in", and then there were other vehicles coming back. So, when they were coming back and change out the drivers, securing the ability the head back north and things like that.", T2*
		operational	1	*"We didn't have the ability to actually get products to customers, but also financially we had to pay significant amount of dollars to get [main food product] and product moved into those regions. Our transport carriers obviously tried to make the most money they could, which obviously is what it is… Some of the vehicle prices which would normally cost a few thousand dollars were being quoted at 25 to 40 thousand dollars. So, huge mark-up!", T2*
		relational	1	*" I would call it the scavenging nature of freight at that time as well where so many times when a crisis like that occurs the first thing that happens is big companies go and secure all the freight and it becomes a bidding war..", T2*

SCRES stage	SCI orientation	SCI type	number of SCs	sample statements
3 –Reconstruction	Government	informational	7 + 1	"*… we would wait communicate with public organisations and coordinate our transportation with them...*", *M2* *"Typically, you're either engaged by emergency services, or it's relying on you to read the papers, and be across these extreme weather events, but, for us, they're more than a informed way.", M4* "*So, ports are very conservative in terms of what they will do when the cyclone is approaching… Then again road operators, infrastructure operators in the public area will be next conservative… Then probably equally as conservative are the large, and even small mine operators… more like they give notice without discussion…Those organisations which are more governmental, so the Pilbara Ports Authority is wholly owned by Western Australian government. WA Main Roads are owned by Australian government. So those organisations typically don't ask for help, and are slow at providing help, and aren't as accountable to shareholders, I guess, as directly as a company like [interviewee's company name] is accountable to shareholders directly*.", L1
		operational	3 + 1	Statement from M2 above describes Informational and Operational SCI Statement from L1 (above) provides interviewee's disappointment in communication and cooperation with governmental organisations
		relational	1	Relationship building in Preparation stage was utilised in this stage. See Preparation, Government, Relational.
	Community	informational	1	*"…[we wanted to] support individuals that lived in that community with getting food to obviously the supermarkets...*", and "*…It is important to actually have product in that area to support, providing food to people.*", T2
		relational	1	
	stakeholders in general	informational	1	*"…you start giving feedback as soon as you are aware of it and you can account for it."* , T1

SCRES stage	SCI orientation	SCI type	number of SCs	sample statements
4 - Recovery	Internal in DAO or interviewee's company	informational	18 + 1	"*Communicate. If you think you're a good communicator beforehand, be a better communicator during that process. The more people that understand what's going on and what you're trying to achieve, the better.*", Q2 "*Communication was based on daily emails where driver would call his network manager and tell him, "There is a flood here. I cannot reach this street or this corner." Then manager would type email and try to share it but it was too slow because managers were not writing mails immediately, obviously. Then the other managers were not next to their mails all the time so they wouldn't see the information on time. Information was repeated here and there et cetera. The reporting back was really difficult. Basically, the two vans that were impacted were drivers trying to drive through puddles, and the vans got stuck", M4*
		operational	15 + 1	"*When that happened and when they put the solution on [island name], they organised a team, a project team with a project leader or a project manager ... So, it was a very well-coordinated effort in terms of, again, as in emergency logistics. Putting up a team that can come up with a plan, with a very safe plan and then getting everyone to do their tasks, and that's why they were successful.*".VE1 "*Close working relationships across our business sectors...We've got a number of touch points across the business…We're growing together, so that works as well…" D1* M4 described Operational SCI -internal coordination being insufficient to support SCRES and creating tangible losses (see the cell above)
		relational	16	*"You know, don't look at the paper. Here, take my hands. We work together, we find solutions together. That human relationship and understanding is valued. ", Q1* *"They put the "right people on the right roads". People that was knowledgeable, not just in the [expertise] area, but they had the capacity to actually influence other people. So, yes, definitely a relationship inside company was important...".VE1*

SCRES stage	SCI orientation	SCI type	number of SCs	sample statements
4 - Recovery	Supplier	informational	9	"*The piece of advice, well, keep good communication, update suppliers and buyers regularly.", M1* *"We would send in daily production schedules or demand schedules on a weekly basis. And then your materials team will appeal to your inventory team in order to communicate with your suppliers and they would sort of ... negotiate a plan how much production they would need to bring forward. Or increase." HS1* *"So, it wasn't uncommon for us to ask the supplier to work overtime to replace a shipment or to make a shipment for us through air freight, to make up for a hole in the pipeline...",PO1*
		operational	7	*"We have to understand how much, as a result of losses, the suppliers understand we will need more and more supplies. They have to sometimes allocate between other supplies, …", T1* HS1 and PO1 from above describe Operational SCI with supplier , too
		relational	7 + 2	"*I had things like building up trust between the supplier and ourselves, building up a good relationship between ", Q1* *"… everyone joins together especially, and in areas, and they try and help you as much as possible. So, I think I'm very good ... We have very good supplies where they try and help us as much as possible, in terms of giving us supplies and invest their resources to sometimes allocate between other supplies…", T1* *"Our suppliers were not affected. They send us their goods ... so they didn't really care", W1*
	Buyer	informational	19	"*Just getting back to those buyers like I said … getting them involved in seeing what's going on*",*Q1* "*So, there was a lot of communication. There was a lot of back and forth communication, of course, in terms of change documents. "Do you really need this to be delivered?" "Yes." "All right, this is what you need to do", VE1* *ET1 described communication with DAO from his, buyer's perspective: "… get back and contact the people who has been at stake, the factory which is closed. How long do they need to recover? How quickly do they need time to recover…*"
		operational	9	*"We do look at working with the customer based for disaster recovery as well for solutions that are outside of our scope on a contractual base." D1* *"It was that give and take. Sometimes they were able to give more, sometimes we were.", T4*
		relational	12 + 1	L1 described buyers as having: "*Very little, very little*" understanding. *"…They expect to be kept informed, they expect to be told what's happening, and they're happy to work with us once they understand that.",* AM1 "*Very close relationship, true integration into each other …we basically work very closely with our supplier. So, we are talking about strategic partnership with our supplier*.", TS1 speaking about DAO from buyer's perspective

SCRES stage	SCI orientation	SCI type	number of SCs	sample statements
4 - Recovery	T&L & DAO	informational	5	*"Also, where we do start to run into trouble, is if you get beyond that two weeks, then the transport network tends to start to fill up with stock that's not moving anywhere, so the railheads become congested. After about two weeks, the transport company start saying, "We can't take any more of your freight. We don't have enough containers. We don't have enough places at railhead," M2* *"We contact those stores and we go on their advice. They'll say, "Don't send anything out." Or, "We're good to accept." Or whatever. Normally what we would do, is anything for those stores, the affected stores... ", T3 from the position of T&L supplier of DAO*
		operational	6	"*We work with them to try and support them through their floods", T3* *"…bring on extra capacity, extra people, extra trucks.", M3* "*So, you've got to work with your production team, you've got work with you materials management team, the logistics team. And your freight forwarder and your supplier and your shipping line. It all has to work together. Otherwise, one person fails to do the wrong thing can bring the whole supply chain down.", HS1*
		relational	6	*"We obviously supported our customers in any way we could, to ensure that their name, if you like, wasn't damaged in the marketplace.", T3 from the position of T&L supplier of DAO* *"… manage relationships with the airlines, so you're getting capacity on the flights into Port Hedland when they reconnect.", L1* *"I guess this comes down to we build long-term, sustainable relationships with larger companies. Particularly, we could go with cheaper, smaller companies, but these events hurt us…", M2*
	T&L & DAO's supplier	informational	2	"*There has been a bit of a history of being a little bit secretive within the business when it came to, "Don't tell the transport company too much. Don't tell the supermarket customers too much." In those situations, there's no such thing as too much, tell them everything they need to know.", Q2*
		operational	1	*"We had meetings on a daily basis with our transport companies [in normal circumstances]. Normally, in these situations [natural disaster affecting the SC], we were probably meeting probably three times a day."Q2*
		relational	2	*"We had mutual understanding of the flood and conditions. Therefore, they were actually understanding towards us, to delay deliveries or pickups". M4 from the position of T&L supplier of DAO's supplier or supplier of DA customers*

SCRES stage	SCI orientation	SCI type	number of SCs	sample statements
4 - Recovery	Government	informational	8 + 1	*"We were in constant link with rails, they would update us on infrastructure availability and provide us with approximate deadlines, when are they starting to operate. We knew here our container was an what is the status of goods. ", W1* *"You use your freight porter…"*, and "*and your shipping line [referring to port and airports authorities]", HS1* *"So that was the big thing, a lot of the companies that we worked with, they all did receive help from the government because it was a lot of funds to set up, a lot of guidance from different people but where our business sat, it didn't qualify for any grants, any help from anyone.", M4*
		operational	3	"*There were times I worked with transport companies to use fire tracks to get into towns that had been isolated. If the road wasn't available…", Q2* *"they [management] had to liaise with the [island name] government in order to start loading bigger cargo planes to land in the island.", VE1*
		relational	1	Lack of strong relationship and communication described as hindering SCRES in Sc M4 under SCI Informational with government, above.
	Buyer's buyer	informational	3	*"… so, whether that is your own relevant stakeholders, there are the suppliers, there are buyers, there are buyers of the buyers, so communication is the key.", T1*
		operational	1	*"It's a lot to do with close coordination and cooperation with the supplier and your customer as well in order to see which one and to reduce the risk this way.", TS1*
		relational	2	*"Customer is quite understanding about the situation… It's always a long-term customer, so they are quite understanding if there's a typhoon hit, they understand that it might be a week or two weeks delay. We are quite impressed by that.", TS1*
	additional stakeholders / community	informational	1	Please see statement provided above under Recovery, Buyer, informational, by T1

SCRES stage	SCI orientation	SCI type	number of SCs	sample statements
5 - Mitigation	Internal	informational	9	*"We go through that [natural disaster management plans] in the initial stage and then that is basically gone through again after an event", D1* *"We share ideas, to update new members on existing positions, this keeps good level of communication, update and knowledge between crisis team members and also informs newcomers on the existing positions very fast and effectively what to do in such a situation, so we are more prepared.", M1* *"At that stage, we were more experienced as a team on the day to day stuff and we'd handled a number of these. We were more proactive and less reactive, because we also had new plans.",* Q2
		operational	3 + 1	*" Typically, we do new stores, so we get to train on setting up a new store, and we get better, and better, and better at it every time. ", M2* *"You should have your practices imagined, crisis situation can be simulated with entire crisis team on board, more you practice better you become even in a stressful environment you will remember what you have concluded together on those practice meetings, so coordination between business units will be better during crisis…", M1*
		relational	2	*"All sectors internally, would meet only fortnightly, sometimes even just twice a year before the extreme event. After that we started meeting more often. We recognised importance of our integration, of coordination, of building understanding", W1*
	Buyer	informational	2 + 1	*"We started communicating with buyers more often and more honestly. Our quality of communication improved", W1*
		operational	1	"*A lot of customers are quite reasonable in working with us and determining what's the best plan of action to try and mitigate any exposure for any future events. We work together on that*.", D1
		relational	1	"*Because of better communication they felt more secured with us, they wanted to continue to cooperate after this flood, and long after it*", W1
	T&L & DAO	informational	1	"*Those suppliers are much more willing to come around the table when you're doing a desktop risk assessment, when they know that I've just gotten through that, [and when you considered] "well we could have actually done some things differently... So, without exception, the haulage companies, port stevedore, airlines, car hire, camp operators, all of those organisations were keen to get involved in* ", L1
		relational	1	