Examining the Resilience of Food Supply Chains Subject to Natural Disasters

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A thesis

submitted in partial fulfilment

of the requirements for the Degree of

Doctor of Philosophy

at

Lincoln University

by

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Lincoln University

2018

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The purpose of this research was to explore the resilience of food supply chains, in response to frequent natural disasters. Building resilient supply chains has recently gained significant attention as a topic, as supply chains have increasingly faced disruptions from natural disasters. Most of the work on supply chain resilience has been theoretical, and many researchers have noted the need for more empirical work on the topic. However, there are still very few empirical studies on the subject and those that are available focus primarily on developed countries. Yet, literature also highlights the increased frequency and impact of natural disasters in developing countries. Furthermore, developing countries constitute a large proportion of world's population and food supply chains are of high importance to fulfill the dietary requirements of people. Food is also a key relief item for humanitarian organizations. While the existing literature provides several strategies and capabilities for improving supply chain resilience, the relationship between these is uncertain. In addition, the underlying activities of each area have yet to be fully explored.

This research presents the findings of research from four different food supply chains, in two different regions, of a developing country. The central aim was to determine the underlying activities of the four most discussed supply chain management areas in the disaster management/relief supply chain discipline (collaboration, knowledge management, logistics, and sourcing) and their relationship with the supply chain resilience components of agility, adaptability and alignment. This research utilizes inductive case study methodology, based on data gathered from a variety of sources. This research has found that the key underlying activities, present in the collaboration among supply chain partners, are the main contributors of supply chain resilience. These activities are also important for knowledge management (KM), logistics and sourcing to work effectively in supply chains. This research has revealed that collaboration, at both vertical and horizontal levels, is critical. At a vertical level, it occurs among supply chain partners such as retailers, wholesalers, processors and growers, while at the horizontal level it takes place with competitors, governments and relief providers.

Closely related to collaboration, this research has found that food supply chains should be engaged in active knowledge management in order to survive natural disasters and to become more resilient. Similarly, this research confirms that speed, flexibility and alignment of interest among different supply chain members are the most crucial element of logistics that are required to effectively deal with natural disasters and that these factors contribute to supply chain resilience. This research also concludes that effective sourcing is critical for supply chain resilience. Sourcing activities such as rationalizing supplier base, through backup suppliers, sourcing from logistically efficient places, and widening and enhancing the supplier base, enable agility, adaptability and alignment, thus increasing resilience.

This research highlights the importance of network structure and social capital as being the facilitating factors for all of the activities present in these four key areas. This research confirms that network structure with large wholesale markets that appear as hubs, facilitate collaboration, knowledge management, logistics functions and sourcing decisions. Closely related to social network, this research confirms that social capital has a positive influence on different activities present in supply chains. Having strong bonds, with high levels of trust and shared values, can further help supply chain members to cope and adapt to the situation. Lastly, this research tells that the activities that contribute towards overall supply chain resilience are inherently present in these supply chains. However, to increase/enhance the resilience against disasters, the actors present in these networks should take measures to increase proactive resilience.

Keywords: Supply chain resilience, disaster management, relief supply chains, collaboration, knowledge management, logistics, sourcing, social capital, supply networks, case study.

Acknowledgements

PhD is a long individual, turbulent, challenging and unpredictable expedition. Along this way, there are many people who provide encouragement, support, love, care and comfort. In this short acknowledgement, it is not possible to list all the people who have encouraged me to complete this journey. First and foremost, I want to express my gratitude to my advisor Dr. Mark Wilson. It was his help, guidance, motivation and generous support that helped me achieve this target. He has taught me how good research is done, not only the research, he has contributed immensely in my personal intellectual growth as well.

I am also very thankful to my associate supervisor, Dr. Jeff Heyl. His contribution towards designing the methodology and data collection were of great importance. I would also like to thank all my seniors who continuously encouraged and motivated me to complete this task.

Financial support by many organizations for this research is highly appreciated, without them it would have been impossible to complete this research. I would especially thank Lincoln University for its financial support to enable me to complete field work and data collection in time. Also, I highly appreciate the administrative support and help of administrative staff in Lincoln University.

My friends have great contribution to make my journey smooth. I am grateful for the time spent with them, all the parties and our trips to mountains will always preserve in my memories. Special thanks to my family for all their love and encouragement. For my parents who always supported me in all my pursuits. For my brothers who understood me and supported me throughout. And most of all, my lovely, supporting, encouraging and enduring wife whose support throughout different stages of PhD is highly appreciated. My daughter, Zainab Umar, my love, my happiness, thank you so much for always cheering your dad. Taha Umar, I know you are looking at my success from heavens. Irteza Umar, thank you for bringing smiles in our life. I dedicate this work to three beautiful ladies in my life: My Mother (Rehana Amjad), My Wife (Bushra Umar), My Daughter (Zainab Umar). Thank you

Muhammad Umar
Lincoln University
October 2018

Publications

Publications from this thesis to date:

1. Umar, M., Rauf, H., Wilson, M. (2014). Humanitarian Relief Supply Chains: A Systematic Review Using Grounded Theory Approach. 12th ANZAM Operations, Supply Chain and Services Management Symposium Proceedings. University of Auckland Business School

2. Umar, M., Wilson, M., & Heyl, J. (2017). Food Network Resilience against Natural Disasters: A Conceptual Framework. *SAGE Open*, *7*(3), 2158244017717570.

3. Umar, M., Wilson, M., & Heyl, J. (2017). The Underlying Activities of Supply Chain Collaboration and Their Contribution towards Achieving Resilience. 15th ANZAM Operations, Supply Chain and Services Management Symposium Proceedings. Queenstown, NZ.

4. Wilson, M., Umar, M., & Heyl, J. (2018). The Application of the Case Study Methodology: Resilience in Domestic Food Supply Chains during Disaster Relief Efforts in South Asia. In *The Palgrave Handbook of Humanitarian Logistics and Supply Chain Management* (pp. 203-245). Palgrave Macmillan, London.

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Chapter 1

Introduction

1.1 Background

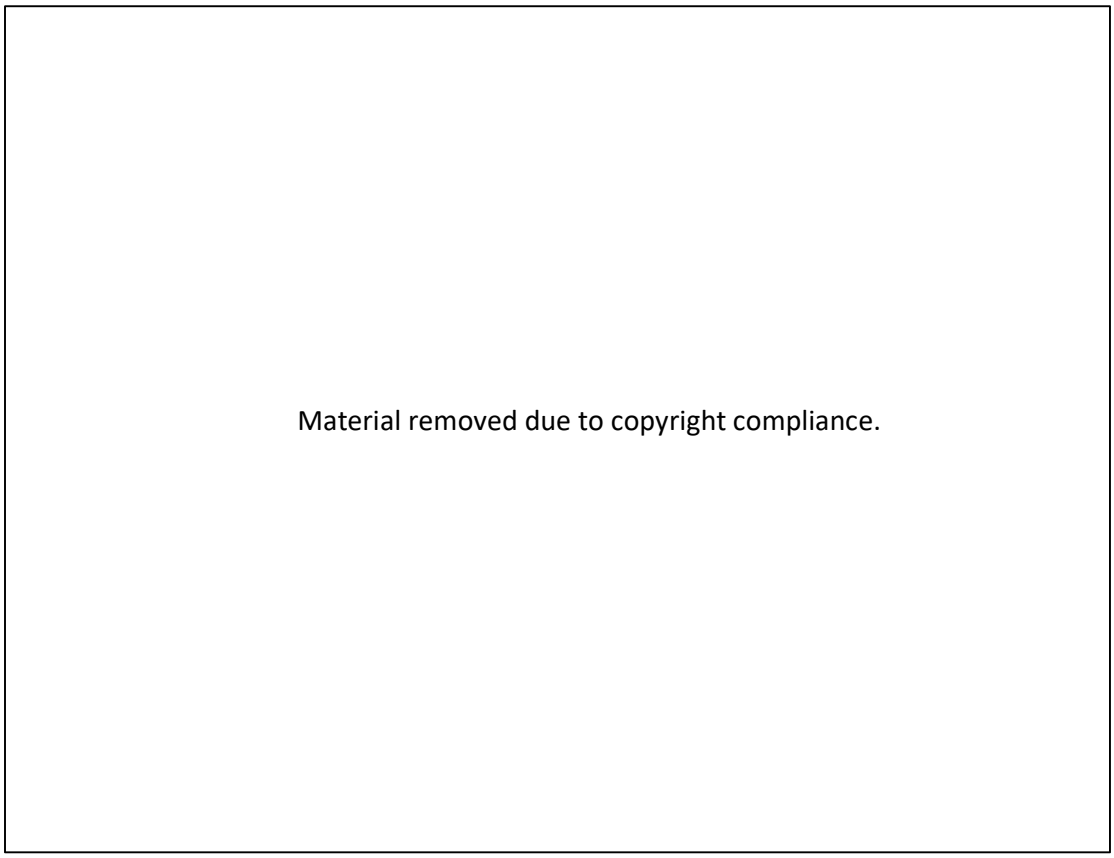
The term 'supply chain' was coined in the early 1980s (Oliver & Webber, 1982). Yet, until recently, the term 'supply chain' was not used widely beyond the boundaries of academia, specialist sectors of industry and some management professionals. However, due to numerous ripple effects of supply chain disruptions on economic activities, the concept of the 'supply chain is now part of the everyday vocabulary of politicians, Non-Governmental Organizations (NGOs), managers and the general public (Christopher & Peck, 2004). Supply chain management covers the planning and management of different activities occurring in sourcing, logistics, distribution, production and retailing. Management, coordination, communication and collaboration with suppliers, intermediaries, customers and third-party service providers is also included in supply chain management (Frankel, Bolumole, Eltantawy, Paulraj, & Gundlach, 2008).

The planning and execution of all supply chain activities is a challenging task that demands efficient and effective coordination of informational, relational and financial flows across the boundaries of a single organization (Ponomarov, 2012). When working effectively and efficiently, supply chains allow products to be produced and transported in the right quantities, to the right place, at the right time, in a cost-effective manner. However, every activity conducted in the supply chain has an inherent risk that can occur due to some unexpected disruption. Disruptions, such as the loss of a supplier, damage to the infrastructure because of an earthquake, or disconnected road transportation due to floods, have the potential to adversely affect both revenues and costs. On occasion, whole businesses are jeopardized due to these disruptions (Ponomarov & Holcomb, 2009). Managing this dynamic risk landscape is an emerging challenge and highlights the importance of the concept of resilience (Pettit, Fiksel, & Croxton, 2010).

The negative consequences of natural disasters are not confined by political boundaries, rather they ripple throughout communities, regions and whole nations. These effects ultimately spread globally throughout the supply chain and impact all entities involved, such

as retailers, producers, governments, financial institutions and end customers. Figure 1.1 (below) highlights the ripple effects of disasters on the supply chain. To reduce the risk associated with disasters, supply chains need to be designed in a way that incorporate event readiness, provide efficient response and be capable of returning to normal after disruption (Ponomarov & Holcomb, 2009).

Figure 1.1 The Impact of Disaster on Supply Chain



Source: (Abe & Ye, 2013)

From a supply chain perspective, risks from natural disasters such as floods and earthquakes, can severely damage business functions and decrease the productive capacity of companies working in the affected region. Natural disasters are a major cause of supply chain disruptions that result in the breakdown of distribution links and production nodes (Handfield, Blackhurst, Elkins, & Craighead, 2007). Literature notes that food supply chains are particularly vulnerable to disruptions (Dani & Deep, 2010; Reddy, Singh, & Anbumozhi, 2016). Food supply chains are essential in any economy, not only because they impact and influence health, hunger, poverty but also the generation of productive employment and livelihoods. A critical assessment of these types of supply chains, especially in the context of disaster disruptions, would provide

an understanding of the key issues involved, and offer opportunities to develop different mechanisms to enhance and secure these critical activities. This will also help in building more disaster resilient communities (Bartos & Balmford, 2011; Berkes & Ross, 2013).

The term 'disaster resilience' in supply chain context can be defined as the ability or capacity of the supply chain to absorb the disruptions caused by a natural disaster. As the consequences of natural disasters can be devastating, enhancing the disaster resilience of supply chains is necessary for all actors involved. There has been an increasing trend in the publication of supply chain risk and vulnerability articles in the last 15 years. Most of the work focuses on the commercial side of business, such as production failures, staff disputes and security issues. There has also been significant work conducted in the context of natural disasters. However, the bulk of the literature has focused on developed economies. This means that there is considerable room to study resilience in developing countries such as Pakistan, India and Bangladesh (Abe & Ye, 2013).

Pakistan is prone to different types of hazards, due to its geographic and climatic conditions. In Pakistan, both man-made and natural disasters result in heavy loss of lives and livelihoods. Such natural disasters include earthquakes, continuous dry conditions, storms, unexpected long seasons of rain and frequent floods. Pakistan faces all of these natural disasters almost every year (Pérouse de Montclos, 2012). The country is also vulnerable to man-made disasters such as terrorist attacks, fire hazards and limited armed sectarian conflict (Rashid & Noel, 2010). The loss of livestock, crops and infrastructure in floods alone has seen Pakistan suffer USD $30 billion of losses in the last 60 years. Over this time, more than eight thousand people lost their lives and more than 400,000 sq.km of land has been affected. In 2010, for example, floods caused a USD $10 billion loss to the economy, 2,000 people lost their lives and total area of more than 160,000 sq.km was affected (Tariq & van de Giesen, 2012).

Similarly in India and Bangladesh, natural disasters are also very frequent, ranging from monsoon rain floods to earthquakes (Haque, 2003). As the economies of these countries depend on agriculture, therefore this sector is mostly affected by these disasters. The economic effects are not limited to the country alone; damage to supply chain operations also affect businesses and markets all over the world. Following a disaster, local governments often require help from private aid organizations, NGOs, logistic companies and local groups to deliver aid; money, medicines, equipment, medical teams, shelter, food and response teams

(Van Wassenhove, 2006). The different challenges of securing these resources, deploying and getting them to affected areas, falls under the discipline of humanitarian logistics and disaster relief supply chain management (P. Tatham, 2012). Potential future risks emphasize the importance of research aimed at strengthening local communities and business to deal with floods and earthquakes (Kovács & Spens, 2007).

Disasters all over the world, both sudden onset and slow onset, have demonstrable effects on food supply chains. Less food is produced and prices increase dramatically due to shortages, thereby increasing world food security concerns (Edwards et al., 2011). Scarcity of food and instability of prices also contributes to social unrest and political instability (Bush, 2010). Different governments also acknowledge the importance of food supply chain resilience and its capacity to return to the normal state once the disaster is over (Kusumasari, Alam, & Siddiqui, 2010; Lawrence, Richards, & Burch, 2013). Hence, the understanding of how communities adapt to certain catastrophe situations, the vulnerability and resilience of food supply chains and the adaptive capacity of different communities are all very important concerns. Food plays a critical role here, both as an economic activity and a relief item, as people need food and water quickly as compared to other relief items (Keogh, Apan, Mushtaq, King, & Thomas, 2011).

Local actors and organizations have a critical role to play in terms of response and resilience, as opposed to donors of humanitarian organizations, who do not necessarily participate in preparations at the local level. Donors insist that their money should go directly to victims once the disaster has occurred. Yet, local actors can provide relief to people, often well in advance of humanitarian organizations reaching the area (Kovács & Spens, 2007).

Managers worldwide experience risk on many levels, especially in times of disasters, no matter the size of the organization. However, the primary source of risk is uncertainty in demand (Simangunsong, Hendry, & Stevenson, 2011). Uncertainty has increased many fold in past few years due to numbers of reasons and these reasons could be result of any natural or manmade disasters. Hence, building a resilient supply chain is a strategic decision which changes the way any supply chain operates and increases the competitiveness of all its actors. Reducing vulnerability means reducing the likelihood and impact of any disruption, and this is achieved by increasing the resilience of the supply chain (Sheffi & Rice Jr, 2005).

Hence, this research will explore the characteristics and capabilities of resilient food supply chains. Capabilities or unique competencies are those attributes, abilities, knowledge and skills that allow a supply chain to achieve superior performance (Ponomarov, 2012). Most of the previous research has mentioned collaboration, knowledge management, sourcing and logistics as important areas in supply chain management that contribute towards supply chain resilience. This research seeks to discover the underlying activities and unique competencies that are associated with supply chain resilience. Since the food supply chain consists of several different actors who make up a large supply network, exploration of network structure and relationships is a central part of this research. As for this research, the different activities in various areas of the supply network need to be investigated. As well as studying the whole supply network, how the relationships work among different actors also need to be explored.

In supply chains, it is not just one firm in operation. Rather, supply chains are made up of multiple firms who organise production, marketing, delivery and the subsequent sale of products and services. It is a group effort that will be influenced by the operations and performance of other firms. The expertise and efficiency of all firms is important to achieve efficient supply chains. As a result, companies often share their resources with other firms to attain success (Batt & Purchase, 2004). Networks can be defined as a structure where different nodes are connected to each other through some source, activity or link (Håkansson & Ford, 2002).

In the complex business environment of supply chain networks, these nodes (vertices) are business units, while the relationships among them are known as links (edges). Supply chains are mostly conceptualized as simple linear systems where firms interact through dyadic relationships (Cox, Sanderson, & Watson, 2001). However, a number of scholars have noted that supply chain networks cannot be conceptualized as simple buyer-supplier relations and furthermore, that they are not always linear (G. Li, Yang, Sun, Ji, & Feng, 2010). Since supply chain networks, including food supply chain networks (Acharyulu & Mathew, 2006), are made up of complex webs of interdependence (made up of suppliers, producers, distributers, retailers and consumers), they must be viewed as complex adaptive systems (Pathak, Day, Nair, Sawaya, & Kristal, 2007). Indeed, Hearnshaw and Wilson (2013) argue that efficient supply chains follow a ‘scale free’ network typology and that this structure has an influence on factors such as supply chain resilience.

In addition to network approach, Resource Based View (RBV) theory provides an important approach in understanding how firms gain or acquire certain capabilities to gain maximum competitive advantage and how such advantages can be sustained (Barney, Wright, & Ketchen, 2001). Most of the early work on the RBV focused on individual resources that firms could develop (Hart, 1995). However, later work has highlighted the importance of network connections through which firms gain or acquire resources (S. D. Hunt & Davis, 2008; Zaheer, Gulati, & Nohria, 2000). Academic interest in this theory has led to its widespread use in the supply chain management discipline (Chen, Daugherty, & Landry, 2009).

Unlike the RBV, that mainly highlights competition between organizations by developing capabilities through internal resources, Relational Exchange theory emphasises inter-organisational collaboration. It posits that firms are embedded in networks with many diverse partners, all of them with different kinds of resources, information and flexibilities (Ozcan & Eisenhardt, 2009). Relational Exchange theory contributes to our knowledge of the dynamics of the 'dyadic relationship' between different actors such as customers, partners and competitors in a network. The relational view states that resources can often span a firm's boundaries and reside in the actual inter-organization relationship itself, such as relational commitment (Dyer & Singh, 1998). These network resources open up new opportunities for firms to gain market capabilities and ultimately reduce uncertainties (Lee, 2007).

In the strategic management literature, competition and cooperation are typically considered separate from each other. However, more recent work revolves around the concept of 'coopetition,' in which competition and cooperation are treated simultaneously. Nalebuff, Brandenburger, and Maulana (1996) coined the term and defined it as "…competing without killing the opposition and cooperating without compromising one's interests" (p. 16). It implies that competition and cooperation can coexist between separate parties and through the same actors in a given network. Companies build capabilities which help them to be competitive, while still enabling them to cooperative with other firms (Bengtsson, Eriksson, & Wincent, 2010a). Similarly, working in groups with mutual trust, respect and coordination makes it easier to achieve common, but complex, targets. This quality of developing synergy in work is called social capital and can be a great tool for responding to, and recovering from, disasters (Aldrich, 2011; Nahapiet, 2008). The rationale of using all of these different theories and how they feature in the study's conceptual framework is explained in the following chapter.

1.2 Research Questions

By exploring the existing theories and conducting an extensive literature review (Chapter 2), in the fields of relief supply chain, food supply chain and supply chain resilience, this research has identified three major gaps in existing research. These are explained in further detail below.

The first gap relates to the lack of an integrated and comprehensive supply chain resilience framework (Pettit et al., 2010; Ponomarov, 2012). While pre-existing literature on supply chain resilience is informative, it provides a fragmented approach to the issue (Christopher & Rutherford, 2004; Park, 2011; Peck et al., 2003; Pettit et al., 2010; Ponomarov & Holcomb, 2009; Sheffi & Rice Jr, 2005). Similarly, several necessary elements believed to contribute to resilience, such as agility, redundancy and flexibility, are typically discussed separately. In short, there is a notable lack of an integrated and comprehensive supply chain resilience framework (Pettit et al., 2010; Ponomarov, 2012).

Secondly, there is a room for more research on sudden onset disasters, such as earthquakes and floods, especially in the context of commercial supply chains. Most of the prior research has focused on risk management aspects of the supply chain. Yet, the major weakness of risk management is its inability to adequately deal with low probability and high consequence events (Kunreuther, 2006; Sheffi, 2015). Resilience can help fill this gap and can supplement the already present risk management knowledge, that will ultimately enhance a supply chain's ability to deal with unforeseen events, and potentially create a competitive advantage. This is particularly apparent in relation to South Asian countries. South Asian countries are prone to natural disasters, and although much work has already been done on relief supply chains consisting of organizations that provide relief efforts, they do not examine the resilience of food supply chains against natural disasters.

Thirdly, although many disaster management scholars have emphasized the importance of collaboration, knowledge management, logistics and sourcing when coping with disruptions (Akhtar, Marr, & Garnevska, 2012; Dorasamy, Raman, & Kaliannan, 2013; Scholten & Schilder, 2015; Van Wassenhove, 2006), there is little information about the specific underlying activities typically found in these areas.

Having identified these research gaps, this study will address these by proposing the follow general research question and sub-questions:

RQ_1: What are the supply chain capabilities that make food supply chains more resilient to natural disasters in developing economies?

a) What are the underlying activities within vertical/horizontal collaboration, knowledge management, logistics and sourcing that contribute to food supply chain resilience?

b) What are the overall facilitating factors that contribute to food supply chain resilience?

c) How do these activities (RQ_1a-b) lead to the higher order supply chain resilience constructs of agility, adaptability and alignment?

1.3 Outline of the Thesis

This thesis is divided into seven chapters. Chapter Two provides a review of the literature on disaster management, supply chain resilience and food supply chains. This is followed by an overview of the specific theories used as theoretical lens in this thesis; network theory, RBV, coopetition theory and social capital theory. This review of the literature and relevant theories provide a foundation for the conceptual framework which is presented at the end of the chapter. In Chapter Three, the research philosophy, methods and design are discussed. More specifically, this thesis employs a case study approach to study four supply chains in two different regions. The data was collected through primary and secondary sources in the chosen regions by conducting fieldwork and consulting key actors associated with these four chains. Chapter Four outlines the study context and includes a description of the two regions and their disaster profiles. Chapter Five presents the detailed case descriptions for each of the case studies and how the networks work. Chapter Six presents and discusses the key research findings, while Chapter Seven summarizes the importance of the study, its key contributions, its limitations and suggestions for future research.

Chapter 2

Theory Development

2.1 Introduction

This study attempts to bring together two disciplines; disaster management and supply chain resilience. The main purpose is to explore the resilience of food supply chains in the context of natural disasters. Hence, this chapter begins with a discussion of disaster management and relief supply chains literature, focusing specifically on the importance of supply chains during periods of disaster. It then considers supply chain resilience and local food supply chain literature to find the relevant supply chain resilience related components needed to develop the study's conceptual framework. This chapter also includes the theories used as a lens for this research.

2.2 Literature Review

2.2.1 Disaster Management and Relief Supply Chains

The term 'disaster' refers to an event that has an adverse impact on the people of that community, their lifestyles, their work and their environment. A disaster can be a result of a natural event or manmade activity. Natural events comprise of floods, hurricanes and earthquakes. Human activities, such as wars and terrorism, that are sometimes referred to as complex emergencies, often leading to the displacement of people for a much longer term, can cause famine and mass migration (PAHO, 2001). Table 2.1 provides examples of each type of disaster.

Table 2.1 Disaster Types with Examples

Material removed due to copyright compliance.

Source: (Van Wassenhove, 2006)

Similarly, The American Red Cross defines a disaster as a situation that results in human suffering, that cannot be alleviated without assistance. Earthquakes, tsunamis, floods, hurricanes, fires, droughts, famine, terrorism, wars and atomic leaks are all included in the disaster category and almost all, have devastating effects on the community involved in terms of injuries, loss of life and property damage (Haghani & Afshar, 2009).

Alexander (1993) has defined a disaster as a fast, sudden event with an immediate impact on the natural environment and the socio-economic system of the society. He recommends Turner (1976) definition which states that, a "…natural disaster is an event, concentrated in time and space, which threatens a society with major unwanted consequences as a result of the collapse of precautions which previously been accepted as adequate" (p. 70).

All of the definitions included above suggest that a disaster is a catastrophe of high magnitude and severity that negatively impacts on communities and the capacities of states and local governments. To determine what represents a disaster depends upon the availability of resources and the capabilities of the responding community/communities. Sometimes even few days heavy rain can be catastropihic and other times with proper management even floods can be managed. This shows that disasters can be managed and prevented by increasing the capabilities of responding organizations.

The World Economic Forum has noted that around 250 million people are affected by natural disasters every year (Howell, 2013). However, only three percent of relief activities are devoted to natural disasters (Van Wassenhove, 2006). This demands that more attention be focused towards natural disasters. Therefore, this thesis focuses only on natural disasters, especially, sudden onset disasters.

Disaster management is a discipline that seeks to mitigate risks and deal with the challenges once disaster has happened. No country or community is immune to the adverse effects of disasters. However, disasters can be prepared for, responded to, and recovered from, and their consequences can be mitigated to an increasing degree (Haddow, Bullock, & Coppola, 2007). Disaster management is a discipline that deals with preparing for disasters before they happen, responding them immediately after their occurrence, and rebuilding communities which inevitably are part of the long-term recovery process. Hence, disaster management is a continuous process. Communities need to have a comprehensive plan and this plan should be continuously updated to reflect changing circumstance (Haghani & Afshar, 2009).

Disaster management is often characterized as a process composed of different phases. Disaster phases, also referred as disaster life cycles, include pre and post disaster stages sub-divided into specific actions. The pre-disaster stage consists of tasks related to forecasting, analyzing and planning related to potential dangers. In contrast, the post disaster stage deals with responses to catastrophic events (Tufekci & Wallace, 1998). Specific phases of the disaster management life cycle vary from author to author. A number of scholars prefer the four phase approach: mitigation, preparedness, response and recovery (Haghani & Afshar, 2009; Safran, 2003). Some authors have included up to six phases into disaster management life cycle (Safran, 2003). DHA (1992) divides disaster management into two phases. The first phase is disaster mitigation (assessment, prevention, preparedness), that deals with the situation prior to a disaster. The second phase is response (relief, rehabilitation, reconstruction), that deals with the aftermath of a disaster. In contrast, Kovács and Spens (2007) separate the disaster life cycle into three phases: preparedness, response and reconstruction.

The preparation phase involves different processes that take place before the disaster occurs. This phase incorporates different strategies that help to ensure a successful response. It is argued that this is the most important phase as, during this phase, all actors are identified; physical networks are designed, communication systems and the basis for collaboration are developed (Van Wassenhove, 2006).

To produce effective results in the response stage, disaster preparedness includes five key elements: human resources, knowledge management, process management, financial resources and the community (Samii, Wassenhove, Kumar, & Becerra-Fernandez, 2002). Human resource preparedness seeks to find trained people who can plan, act, do and coordinate in disasters. Knowledge management means to find, codify and interpret the data required for effective management in disasters. Process management is about streamlining all of the processes in managing a disaster. Financial resources preparation is about finding donors and raising money to provide relief to the people. The last item is community, that entails finding effective coordination and collaboration among key actors (Van Wassenhove, 2006).

Once a disaster has struck, the first 72 hours are crucial and speed at any cost is most important. In these 72 hours, goods need to be transferred from abroad as quickly as possible.

The next 90-100 days, organizations consider their effectiveness, as well as cost of the relief effort (Van Wassenhove, 2006). This period constitutes the response stage of a disaster. Indeed, Cozzolino, Rossi, and Conforti (2012) define the response phase as the phase that involves various operations that are immediately implemented after a disaster occurs. They divide the response phase into two sub-phases. In the first sub-phase, the concern is to save lives by activating temporary networks (that is, coordinating different stakeholders). The second sub-phase is to restore basic services and food deliveries to most of the victims.

In the response phase, the main concern is with *time* and *speed* as the focus is to save lives. The reconstruction phase is concerned mainly with the aftermath of the disaster and is marked by a gradual reduction in speed. Day, Melnyk, Larson, Davis, and Whybark (2012) also explains that relief supply chains do not concentrate on profit and loss, rather it is concerned primarily with matters of life and death (Cozzolino et al., 2012).

This research is focused on supply chain management, within the broader field of disaster management. The definition of supply chain management varies from area to area. In the military, it can be defined as the science of planning out the movement and maintenance of force dealing with designing, acquisition, storage, transportation and distribution of material on the one hand and, on the second hand, movement, evacuation, transportation and the deployment of personals (US-Military, 2005). In commercial businesses, it can be defined as the management of materials, information, services and capital flow to provide superior customer services (Chopra & Meindl, 2007). In the humanitarian context, supply chain can be defined as the process of planning, implementing and controlling the flow and storage of relief items, as well as information and finances, from the point of origin until they reach the point of utilization (Thomas & Kopczak, 2005). No matter the definition, planning, procurement, transportation, storage, inventory, tracking, allocation and customer satisfaction are the key elements of all supply chains.

Although disaster relief supply chains deal with special challenges, the basic philosophies of commercial supply chains are still valid and can therefore be applied to this sector. However, there are certain specific characteristics that make relief supply chains unique. In these chains, demand for relief is unpredictable and often multiple organizations and volunteers are involved. Potential customers (those affected and the donors who are funding the response) are also different than the commercial supply chains. Moreover, transportation is often

limited and the local infrastructure is typically degraded or paralysed. All of these issues make disaster supply chain management very challenging when compared to business supply chains (Kovács & Spens, 2007). The coordination of many different relief organizations, suppliers, local NGOs and local retailers, all with their own ways of operating, is very demanding. A lack of clarity can create problems with the 'last-mile' of aid distribution. In coordinating supplies, aid agencies can sometimes source from local suppliers. Local retailers are often the first relief workers who help in the event of a disaster. In most cases, they have the advantage of strong local knowledge, reduced transportation needs and are more likely to fulfill the dietary requirements of the local population (Garry, 2005; Horwitz, 2009b).

Day et al. (2012) has also described the uniqueness of the humanitarian supply chain. There are often conflicts relating to authority and delays in decision making in relief supply chains because of uncertainty about who is in charge or how best to meet the needs of the people. Disaster relief operations are dependent upon donor organizations to provide goods and services, in addition self-initiated participants also make these supply chains highly variable (Van Wassenhove, 2006). As such the presence of high uncertainty makes these rather unique supply chains. Uncertainty is an element of risk, however risk can be estimated through probability distributions of an event taking place and the likely impact of the event. Yet, uncertainty throws these probability estimations into doubt, such as the unpredictability of earthquakes.

Kovács and Spens (2007) states that relief supply chains share certain similarities with commercial supply chains; these are demand management, supply management and fulfillment management. Beamon (2004) claims that relief supply chains have unique characteristics related to the particular nature of disasters, when compared to business supply chains. Relief supply chains are fundamentally different from commercial supply chains in terms of supply and demand characteristics, strategic goals and environmental factors. The issues that introduce complexities into relief supply chains are: demand patterns, lead time, inventory management, information or knowledge systems, strategic goals, and fragmented and congested distribution networks.

Demand information is crucial to relief operations. Formulae do not exist to accurately forecast resource requirements, both in terms of types and quantity. Different links in the relief supply chains have very weak connections so it is difficult to predict what is/is not

needed at the next stage (Day et al., 2012). In demand management, considerations of cultural norms of the disaster region are also included. Demand is totally unpredictable in respect of timing, location and scale. Hence, humanitarian supply chains are the most dynamic type of supply chains (Kovács & Spens, 2007).

Similarly, in terms of supply management, relief agencies receive many unsolicited supplies. These can include medicines and food that have passed their expiry dates. These unwanted supplies block airports and warehouses. In many cases, aid agencies must rely on local suppliers to provide food, medicine and shelters. This point is important for this research. During the relief efforts, fulfillment management is the most challenging factor, due to poor infrastructure. For example in the aftermath of the 2005 Pakistan earthquake, the roads in the affected area were virtually nonexistence, further there was a critical shortage of vehicles and fuel.

It is also difficult for humanitarian organizations to control costs because of the high demand of uncertainty. There are four main costs involved in relief chains; transportation costs, inventory holding costs, distribution costs and administrative costs (Akhtar et al., 2012). Better coordination among different stakeholders helps reduce costs. However, managing inventory holdings, as well as transportation costs, are really challenging in relief chains, due to variations in demand and damaged infrastructure.

In addition to demand and supply management, order fulfillment should also be very efficient in humanitarian supply chains. In the case of relief supply chains, time between actual demand occurrence and supplies requirement is almost zero (Beamon & Balcik, 2008). The lead time should be as short as possible since demand needs are parallel, and these needs can dramatically affect the procurement and availability of relief items. Here, coordination plays a key role (Uddin & Hossain, 2011). All parties should have regular updates concerning demand patterns, especially retailers, and transporters should have a clear idea of the activities they will be undertaking. Transportation routes and vehicles are often not reliable in the case of disasters. The demand in most locations is not known with any accuracy. In the case of last mile distribution, transport availability plays a key role in order fulfillment.

Food prices also affect demand and Beamon and Balcik (2008) state that prices of food related items increase significantly during disasters. These price fluctuations can be moderated if organizations work together. Companies should not rely on a single source, but rather, should

choose multiple sources for procurement. They can also negotiate with transporters to reduce prices for humanitarian crises.

Although demand, supply and order management should be properly managed and tightly coordinated in turbulent times, there are certain issues that make this difficult to achieve. These issues include logistics and transportation failure, lack of performance measurement systems and improper knowledge management, during times of disaster. For example, Perry (2007) has identified different logistics issues in supply chains in the days immediately after 2004 tsunami in Banda Aceh. There were limited modes of transportation and physical infrastructure (roads, bridges, and telecommunication systems) were also destroyed. Peck (2006) also points out that transportation failures, such as due to logistics infrastructure damage, is a significant source of supply chain vulnerability. Logistics damage can be divided into three broad categories: damage, loss and delay (Perry, 2007). Damage and loss cause discrepancies in demand, stock levels and data availability. Yet, in an age of just-in-time inventory management, delay is considered a greater concern than damage or loss. As a solution to these problems, Perry (2007) has emphasized the need for thorough knowledge of local suppliers and local transportation assets.

Knowledge management plays a crucial role in managing the disrupted food supply chains. The speed with which information is collected, analyzed and translated into knowledge and distributed by the participant agencies is very important for effective response during disasters (King, 2005). Preparedness and response stages are totally dependent on this information. Information should include basic knowledge such as, the availability of resources, the affected area and population, the impact of the disaster, and need assessments (Zhang, Zhou, & Nunamaker Jr, 2002). Hence, improving the synchronization of activity, money and resources in relief services depends on good knowledge management systems (Day et al., 2012).

As relief supply chains and the disaster management discipline has recently come to the attention of researchers (Altay & Green III, 2006), most of the research to date has been concerned with exploring the field and pointing out the problems associated with relief supply chains. Some scholars have attempted to develop frameworks and solutions for these issues. For example, the Kovács and Spens (2007) framework studies the links between different actors and phases of relief operations. They group actors involved in disaster relief operations

into two major categories: regional actors and extra regional actors. Regional actors are those who exist in the region like military, host governments, local enterprises (retailers) and local aid agencies. Extra regional actors include the United Nations, large aid agencies, international NGOs and logistic providers. Similarly, relief operations can be divided into three phases; the preparation phase (the time before the disaster occurs), the immediate response phase (immediately after the disaster occurs) and the reconstruction phase (the period after the disaster when efforts to rebuild the community happens) (Allen, Kovács, Masini, Vaillancourt, & Van Wassenhove, 2013; Kovács & Spens, 2011).

Although there are differences between humanitarian logistics and business logistics (demand uncertainty, lack of coordination, lack of infrastructure) (Beamon, 2004), the tools and techniques actors need in relief operations can be adapted from business logistics. Risk management will help local actors during the preparation phase, while extra regional actors can work on strategic planning during this stage. Regional actors can use crisis management or vulnerability analysis techniques during the immediate response phase and extra regional support can adapt short-term project management philosophies from business logistics during this phase (Kovács & Spens, 2007). Subsequently, local actors can use business resilience and continuity planning during the reconstruction phase, while international agencies can work on long-term project management. Kovács and Spens (2007) conclude their study by calling for further research on the links between these two groups of actors and how these actors implement risk management, crisis management and business resilience philosophies.

Kapucu (2008) provides an additional solution using learning theory. The complexity of response operations demands a flexible learning approach, that involves all members of society, whether organizations or individuals, to adjust their performance according to local demands and conditions. For instance, in the response stage of disaster, organizational learning theory can be used to understand community coordination. Here, new knowledge and insights can often be generated as a result of a crisis. Organizations and individuals learn through processes of knowledge generation and acquisition, information dissemination, organizational memory and information interpretation (Scholten, Sharkey Scott, & Fynes, 2010).

Different scholars (Balcik, Beamon, Krejci, Muramatsu, & Ramirez, 2010; Beamon, 2004; Day et al., 2012; Kovács & Spens, 2007) have discussed humanitarian organizations in a time of

crisis. Concurrently, commercial supply chains, especially food supply chains, also face similar problems as relief supply chains during time of disasters. As food is also necessary for providing relief to people, the significance of food supply chains, is critical compared to other commercial supply chains (Bartos & Balmford, 2011). In comparing humanitarian supply chains with commercial supply chains, Van Wassenhove (2006) has proposed that business supply chains can adopt important strategies, such as quick response, coordination and adaptability from relief supply chains.

Although there is an increasing trend in research on relief supply chains of humanitarian organization, there is little discussion of how local commercial supply chains survive during disasters. This thesis seeks to position itself within this gap.

As mentioned above, disaster management and relief chain literature tends to emphasize four main areas of the supply chain which are important during periods of disaster: these are knowledge management (Islam & Chik, 2011; King, 2005; Pathirage, Seneviratne, Amaratunga, & Haigh, 2012; Zhang et al., 2002), sourcing decisions (Ertem, Buyurgan, & Rossetti, 2010; Kovács & Spens, 2007; Van Wassenhove, 2006), collaboration among different supply chain actors (Asgary, Anjum, & Azimi, 2012; Jahangiri, Izadkhah, & Tabibi, 2011) and logistics operations. (V. Jain, Jain, John, & Ramesh, 2012; Jensen, 2012; Liberatore, Ortuño, Tirado, Vitoriano, & Scaparra, 2014; Sandwell, 2011). However, individual activities within each of these areas is underexplored in the literature. As stated in the research questions, this research will explore the activities in these four areas and will present their linkages with supply chain resilience components. Before examining the resilience literature, it is first necessary to see how these four areas are discussed in the relevant literature.

2.2.1.1 Collaboration

Supply chain collaboration refers to inter-organizational relationships, that ranges from common supplier relations, to coopetition where firms collaborate with their competitors to gain a bigger client base (Bengtsson, Eriksson, & Wincent, 2010b). Collaboration means that two or more organizations work together to ensure that their supply chains run smoothly; this may include information sharing, joint planning, combined decisions and the sharing of resource (Simatupang & Sridharan, 2002). Collaboration works like glue, holding together different firms and enabling them to achieve those all capabilities that are necessary for combating any disruptions in the supply chain. Indeed, supply chain collaboration can be

divided into two main categories, vertical and horizontal collaboration (Barratt, 2004). During any disruption, firms collaborate with relief providers, governments, and with their competitors at a horizontal level. Similarly, at a vertical level, these organizations collaborate with suppliers and buyers (Piboonrungroj & Disney, 2015).

The literature on supply chain collaboration focuses primarily on the different types and stages of supply chain relationships (Knoppen & Christiaanse, 2007). Further, it talks about the relationship of these stages to particular strategies and theoretical foundations (M. Cao & Zhang, 2012). The types of relationships discussed in the literature include transactional, relational and fully coordinated (Barratt, 2004; Simatupang & Sridharan, 2002). Other popular topics include, trust and commitment, reward systems and power among the supply chain actors (Min et al., 2005). Several collaborative elements have been identified in the supply chain collaboration literature. Such as Simatupang and Sridharan (2002) have proposed that information sharing, decision alignment and incentives are important elements of supply chain collaboration. Information sharing describes the extent to which supply chain members share information with each other in efficient and effective ways (Kim, Umanath, & Kim, 2005). Decision synchronization or alignment is an integrated approach to making decisions. It can happen at different levels of the supply chain and between different members; for example, delivery schedules can be decided by both the logistic company and the manufacturer (Piboonrungroj & Disney, 2015). Incentive alignment refers to the sharing of risks and benefits among supply chain partners (Maon, Lindgreen, & Vanhamme, 2009).

M. Cao and Zhang (2012), is one of the most widely cited works on supply chain collaboration. They have identified seven components of supply chain collaboration that can be present among the supply chain members to achieve common goals and mutual benefits. These elements are information sharing, goal alignment, decision synchronization, communication (Prahinski & Benton, 2004), joint knowledge creation (Hardy, Phillips, & Lawrence, 2003), resource sharing and incentive alignment. Scholten and Schilder (2015) have also used these elements to investigate the role of collaboration in supply chain resilience. Further importance of supply chain collaboration in supply chain resilience is discussed later in this chapter.

2.2.1.2 Knowledge Management

Knowledge is a mixture of values, contextual information and expert judgment that provides valuable insights to evaluate experiences and information (Davenport & Prusak, 1998). It is

also defined in terms of data and information. Many authors, however, are of the view that knowledge is more than data and information (Alavi & Leidner, 2001). Data is just raw facts and figures, yet when data is given a context, it becomes information. Additionally, when this information is processed and contextualized by some actor or organization, it becomes knowledge (Nonaka, 2008).

Knowledge can be divided into many different types, including tacit, explicit, individual, group, indigenous, public and private knowledge (Nonaka & Takeuchi, 1995). However, most of the literature focuses on tacit and explicit knowledge. Tacit knowledge is situation-specific knowledge or information that resides in individual's minds or within the routines and culture of the organization. This type of knowledge is difficult to store and distribute (Davenport & Marchand, 1999). In contrast, explicit knowledge can be stored, codified and used by others (Nonaka, 2008). Additionally, indigenous knowledge is a form of knowledge that is practiced, maintained and developed by local people or the community. For example, people with an extended history of interaction with each other and with specific natural disasters, develop special ways to form and share knowledge that are specific to that area (Agrawal, 2014).

Knowledge management (KM) is the creation, extraction, transformation and storage of information to develop good policies in order to achieve positive results (Horwitch & Armacost, 2002). Similarly, Choy (2006) defines it as a systematic process to acquire, store, share and use knowledge for creating better value for businesses to achieve competitive advantage. Knowledge management capabilities are typically divided into two categories; knowledge infrastructure capabilities and knowledge management processes (Bharadwaj, Chauhan, & Raman, 2015; Gold & Arvind Malhotra, 2001).

Gold and Arvind Malhotra (2001) refer to three important infrastructure capabilities for knowledge: technical, structural and cultural. Knowledge management infrastructure is the building block of effective knowledge management. The role of technology, especially IT and telecommunications, in KM is greatly emphasised (Choy, 2006; Chua, 2004). The culture of sharing and respect also facilitate KM processes (Holsapple & Joshi, 2000; Pan & Scarbrough, 1998). Similarly, Zaied (2012) argues that sharing and collaborative cultures enable efficient knowledge processes. The structural aspect plays the most crucial role in facilitating KM processes and enabling supply chain members to adapt to disruptions. Network structures

that are cohesive and collaborative are also critical to the speedy transfer of knowledge (Reagans & McEvily, 2003).

KM processes are activities which facilitate the acquisition, creation, sharing and utilization of knowledge in order to gain better position in the market (Alavi & Leidner, 2001). These activities are equally important for dealing with disasters in an effective way, as described in disaster management literature (Dorasamy et al., 2013). Different scholars have categorized these processes in different ways, however, the most common categories are, acquisition, sharing and utilization (Andersen & Center, 1996; Demarest, 1997; Nonaka, 2008).

Knowledge acquisition is the primary process. It refers to the acquiring and capturing of new knowledge. This can be in the form of learning from past experiences and/or improved use of exiting knowledge (Drucker, 1998). Learning is the most important element here and is also emphasised by disaster management scholars (Barnett & Pratt, 2000; Choy, 2006; Lu, Goh, & De Souza, 2013). Lu et al. (2013), based on the work of Huber (1991) & Tsang (2002), have proposed four learning mechanisms of learning in difficult times. These are, learning by hiring (grafting learning), learning by doing (experiential learning), learning by observing (vicarious learning) and learning by searching (searching).

The sharing of knowledge can be done in many ways. One can be through formal training among supply chain members, where one member provides guideline and training to another less experienced member (Allen et al., 2013; Choy, 2006). The other is a more informal method, sometimes called socialization, where two supply chain members come together at a common place to interact and share knowledge. This coming together, sharing insights and transferring knowledge increases the absorptive capacity of supply members, thus making them more adaptive (Harri Laihonen, 2015). Finally, utilization, is an aspect of knowledge management where knowledge is used to deal with specific situations (Bharadwaj et al., 2015; Eriksson, 2009).

2.2.1.3 Logistics

The importance of logistics has already been highlighted in the review of disaster management literature above. Logistics plays a primary role in responding to, and recovering from, any natural disaster (Beamon & Kotleba, 2006). Logistics is required to support supply chain members in the form of efficient and effective transportation, storage and inventory activities (Bemley, Davis, & Brock III, 2013; Chandes & Paché, 2010). There are number of challenges

that emergency logistics face during or after a disaster, such as unusable routes, safety issues, demand uncertainties, breakdown of normal communication systems, the involvement of local governments, delivery delays and limited resources (Beamon & Balcik, 2008).

Logistics deals with the flow of material and information throughout the supply chain. It encompasses transportation, production, inventory management, storage and warehousing (Gunasekaran, Lai, & Edwin Cheng, 2008). Transportation is the part of logistics that makes it possible for products to reach their target destination in a timely and safe manner (Stephenson Jr, 2005). It not only includes the means of transportation, but also, all of the alternatives of getting supplies from one point to another such as routing (Roy, Brewster, & Albores, 2012).

Storage or warehousing is another important element of logistics. It is a systematic and organized way to protect the product until it is delivered to the customer. Waters (2009) states that warehousing is the management of storing and holding inventories. It includes issues such as facility location, layout and design, storage and preserving the items for later use. Another closely related component of logistics is inventory management. It is one of the largest assets of any organization. Every product is considered as inventory at some stage of the supply chain. Management of these products is important for the overall efficiency of logistics management (Kenyon & Meixell, 2011).

Packaging is also considered to be part of logistics. Chan, Chan, and Choy (2006) state that good packaging techniques provide benefits for storage, inventory management, handling and distribution of the product. Mollenkopf, Closs, Twede, Lee, and Burgess (2005) also consider packaging as a value adding activity. They note that if done properly, packaging can be very effective for marketing and the handling of products.

All areas of logistics (transportation, storage and inventory management and packaging), must be fine-tuned to quickly and efficiently respond to natural disasters (Beamon & Kotleba, 2006; Dani & Deep, 2010; Davidson, 2006; Roy et al., 2012). This review next examines sourcing.

2.2.1.4 Sourcing

Several scholars have highlighted the role of the sourcing in effective disaster management in the humanitarian relief supply chain context (Ertem et al., 2010; Singh-Peterson & Lawrence,

2014). These scholars provide a variety of strategies to prepare for and quickly respond to disasters, including local sourcing, multiple suppliers, and narrow supplier base.

Sourcing is the process by which organizations find the suppliers for specific business needs (Choi & Hartley, 1996). Strategic sourcing refers to a systematic way of managing the supply base. It involves the identification and selection of suppliers in the network and not only includes selecting suppliers but also developing long-term relationships (Talluri & Narasimhan, 2004).

There are number of strategies discussed in the literature to achieve effective sourcing in supply chains (Choi & Hartley, 1996; Choi & Wu, 2009; Ertem et al., 2010). Yi, Ngai, and Moon (2011) explain that supply chain members can utilize flexible sourcing strategies to enable continuous availability of supplies and suppliers even in difficult times. As Jüttner and Maklan (2011) note, it is important to have the ability to choose cost effective and alternative suppliers, particularly in times of crisis. Roberta Pereira, Christopher, and Lago Da Silva (2014) also highlight the sourcing flexibility role in reducing lead times and mention its critical role in achieving supply chain resilience through agility. Multiple suppliers, or dual sourcing, is seen as a way to achieve sourcing flexibility. Dual sourcing is where buyers procure products from at least two sources, such as a less experienced, as well as a more experienced supplier, with the aim of achieving greater volume flexibility (Chopra & Meindl, 2007; Tomlin, 2006).

Y. Wang, Gilland, and Tomlin (2010) highlight the importance of developing just a few key suppliers. Collaborative efforts and relationship management then becomes easier for these suppliers and can increase the overall responsiveness of these supply chains. Regardless of how many suppliers are part of a sourcing strategy, firms do establish long-term relationships with their suppliers. These can be developed normatively by repetitive business, as well as having long-term contracts (Sheffi, 2015). Interestingly, it has been observed that companies who are involved in long-term relationships respond and recover from disasters quicker than others (N. Jain, Girotra, & Netessine, 2016).

Sourcing from logistically efficient places is also seen as an important strategy to reduce cost and increase overall efficiency (Hausman, Lee, & Subramanian, 2005). The financial situation of the supplier is also highlighted as important criteria for supplier selection. Zsidisin, Panelli, and Upton (2000) state that if a supplier's financial situation is vulnerable, then this supplier may go out of business in the future. Having a smaller supplier base is also a key strategy for

quick responses as they are generally easier to manage (Sheffi & Rice Jr, 2005; Simangunsong et al., 2011).

2.2.2 Supply Chain Vulnerability and Resilience

Supply chains are complex networks of organizations (Hearnshaw & Wilson, 2013) that experience nonstop turbulence. This create the potential for unpredictable disruptions. According to different authors, the greatest threat or risk area is an organization's supply chain (Global, 2007; Micheli, Mogre, & Perego, 2014).

Even though there are many ways to define supply chains, this research adopts the following definition; a network of companies involved in both the upstream and downstream movement of raw materials, products, finances, information and services from the very first supplier to the end customer (Mentzer et al., 2001). Different kinds of turbulence and a high degree of complexity in supply chains demand an enterprise view with coordination among all business functions, not only within the company but also between companies through inter-organizational alignment (Slone, Mentzer, & Dittmann, 2007). However, due to environmental changes, supply chains have become more complex and vulnerable, thus adding to potential supply chain disruptions (Pettit et al., 2010). Hence, organizations must learn to foresee, absorb and overcome disruptions (Pickett, 2006).

2.2.3 Different Methods to Counter Disruptions

From the early nineteenth-century, the main strategy to counter supply chain disruptions was holding inventory. Safety stock to deal with uncertainties remained a key strategy for a long period of time. With the advent of the service sector, customer satisfaction became the key metric for supply chain managers, rather than cost containment through inventory carrying costs, production costs, transportation costs and distribution costs (Kent & Flint, 1997). To satisfy customer demand quickly and to manage risks, quick response mechanisms were developed by researchers such as vendor managed inventory (VMI), and just-in-time (JIT) (Tan, 2001). However, these quick response systems have increased the vulnerability of supply chains to disruptions. The reason is that they reduced buffer and safety stocks. In this newer model, supply and demand is more closely linked, yet in turbulent times, there are more chances of disruption to these types of supply chains (Wagner & Bode, 2009).

Krafcik (1988) coined the term 'Lean manufacturing' in the late eighties to refer to reductions in costs due to global production. Lean is a manufacturing ideal that reduces the timeline between customer order and delivery by eliminating waste (Liker, 1997). Waste is defined as any non-valued activity. Lean manufacturing does not mean that inventory can be stored in the warehouse and shipped immediately when the customer orders it. It means that manufacturing is conducted only when the customer order is known, and the total lead time is kept as short as possible. If product is waiting anywhere in a queue, this is viewed as a waste. However, this philosophy also has its limitations in dealing with disruptions. For instance, with little inventory at each step of processing, there is less buffer capacity to deal with disruptions and limited opportunities for innovation (Melnyk, 2007). Similarly, applying Total Quality Management (TQM) principles, like the Six Sigma philosophy, also provides leverage in achieving higher supply chain resistance against disruptions and reducing risks by reducing operating costs (Kleindorfer & Saad, 2005). However, in the six-sigma approach there is a little flexibility to deal with disruptions. As the core philosophy of six sigma revolves around continuous improvement; by driving out process variability, wastes and compressing time (Christopher & Rutherford, 2004).

While Lean manufacturing and six sigma are the dominant production paradigms currently, the idea of resilient supply chains has also risen to prominence lately. The following section develop the concept of resilience by reviewing literature on vulnerabilities and different techniques to foresee, mitigate and recover from disruptions.

2.2.4 Supply Chain Vulnerability

Researchers have studied and explained supply chain vulnerability (SCV) in different ways. Some have studied SCV conceptually (Brooks, 2003; Singh-Peterson & Lawrence, 2014; Svensson, 2000), some have studied it analytically (Bakshi & Kleindorfer, 2009; Stecke & Kumar, 2009) and some also provide empirical support for the concept (Wagner & Neshat, 2012). Table 2.2 provides some key definitions of supply chain vulnerability derived from literature. Most definitions discuss two main characteristic of supply chain vulnerability; that of 1, supply chain design variables, and 2, the supply chain's environmental factors. Singh-Peterson and Lawrence (2014) define vulnerability as the degree of a system's susceptibility to disruptions and its ability to cope with these changes. Asbjørnslett (2009) notes that vulnerability can be assessed by studying supply chain processes, infrastructure and its

operations. Bakshi and Kleindorfer (2009) consider vulnerability as a combination of infrastructure and environmental factors.

Whenever a disaster occurs, whether slow onset or sudden, a supply chain disruption is often triggered because of certain risks present in the supply chains. However, these risks are not the only determinant of final loss. Wagner and Bode (2009) state that the degree of susceptibility of a supply chain to these harms is also important. This helps explain the concept of supply chain vulnerability, that shows that the probability of any disaster occurring, as well as the severity of supply chain disruptions, must be considered.

Table 2.2 Definitions of Supply Chain Vulnerability

Authors	Definitions
(Singh-Peterson & Lawrence, 2014, p. 785)	"...degree of a system's susceptibility to disruptions and its ability to cope with these changes. It aimed to determine systems sensitivity to change and its inability of response to sudden change".
(Bakshi & Kleindorfer, 2009, p. 588)	"...probability of occurrence of disruption. This possibility is determined by kind of infrastructure and combination of environmental factors".
(Asbjørnslett, 2009, p. 17)	"…a concept that characterize supply chain's lack of resilience with respect to threats from both within and outside systems boundary".
(Svensson, 2000, p. 732)	"...condition that is result of time and collaboration dependencies in a firm's business activities in supply chains".
(Jüttner, Peck, & Christopher, 2003, p. 206)	"...tendency of risk sources and drivers to outweigh risk mitigating strategies which result in worst supply chain consequences".
(Wagner & Bode, 2009, p. 304)	"…function of certain supply chain characteristics and the loss a company bears is the result of supply chain vulnerability to a given supply chain disruption".
(Neil Adger, 1999, p. 251)	"...degree of loss as a result of disaster. It is exposure of community or individuals to stress as a result of social or natural change".
(Wisner, 2004, p. 11)	"...characteristics of an individual or a group in terms of their capacity to foresee, cope with, resist and recover from impact of some disruption".

According to Wagner and Neshat (2010), certain drivers underly supply chain vulnerability. They categorize these drivers into three groups: demand side, supply side and supply chain structural vulnerabilities.

On the demand side, vulnerability drivers can be seen in downstream supply chain operations. This includes the product and its features, customers (the financial situation of the customers, and customer dependence), the outbound supply chains (distribution of products to end customers) and transportation. It can also include uncertainty in random demand patterns of customers. On the supply side, these drivers reside in the supply network, suppliers' portfolio and supply base. Supply chain structures (lean or agile, global) also play a major role in assessing supply chain vulnerabilities. Indeed, supply chain structures are becoming more complex, with fewer inventories, global sourcing, multi suppliers and leanness making supply chains more fragile. (Wagner & Neshat, 2010)

Pelling (2003) identifies three components of vulnerability: exposure, resilience and resistance. Altogether, these three are the products of socio-economic and political structures, and test the capacity of different actors to adapt to hazards. Adaptation is a key concept in vulnerability. If the exposure to a hazard refers to the risk of flood water, or damage due to an earthquake, then resistance and resilience refer to an individual's capacity to minimize the negative impact through some form of adaptation.

Sheffi and Rice Jr (2005) introduce a vulnerability framework based on the likelihood and the impact of a disruption. Vulnerability is highest when both likelihood and impact are high. Events that have low impact and low probability of occurrence are very rare and require little planning. Events that have high probability and low impact can be managed by daily operations management. However, events that have low probability and high impact required proper disaster planning and response strategies. According to these authors, firms can create an enterprise vulnerability map by placing different threats in the relevant area of their vulnerability framework.

Singh-Peterson and Lawrence (2014) have used vulnerability analysis to study the adaptive capacity and resilience of local communities in times of crisis. Yet the scope of their study is limited to the Australian food supply chain, with a focus on retailers. Singh-Peterson and Lawrence (2104) first highlight the exposure sensitivities, such as food prices increasing after the flood, food availability immediately after the floods, and how energy prices impacted the

situation. Secondly, they noted the coping mechanisms and adaptive capacity for retailers and also the local community (Table 2.3). They also discuss the coping strategies of consumers following the flood, like their decreasing food intake and closure of local restaurants. They noted large retailers' inability of sourcing the products due to a lack of pre-existing relationships with suppliers (Singh-Peterson & Lawrence, 2014).

Table 2.3 Coping and Adapting Strategies of Food Supply Chains

Coping Strategies (Immediately after the Disaster)		
1	Large Chain Supermarkets	Supermarkets were unable to find local sources. They sourced from distant markets for the first two weeks of disaster. Due to large financial resources, they absorbed the shock of the first two weeks.
2	Small Retailers	Small retailers in these areas sourced fresh food from local sources at reasonable prices. Some of them hired agents who brought food from distant areas but they passed the expenses onto customers (increased prices)
3	Community	Many local community members preferred to buy frozen and canned food instead of fresh vegetables. Many of them stored food before the disaster for two weeks.
Adaptive Capacity		
1	Retailers	Small retailers, as compared to large ones, in areas without major disruptions, were able to depend on local produce when long supply chains were disrupted. Large retailers could amplify their adaptive capacity by approaching and supporting local food systems. This could be achieved by building relationships with local growers.
2	Community	Several small retailers advocated for local farmers and were a contact point between farmers and customers. To improve adaptive capacity, the community could support local food initiatives and advocate for large supermarkets to support local food supply chains.

Adapted from: (Singh-Peterson & Lawrence, 2014)

Organizations that achieve a form of competitive advantage in the market tend to master their current supply chain challenges (Vogus & Sutcliffe, 2007). These companies often consider strategies like outsourcing, supplier partnership, inventory reduction management, reduction in supplier base and single sourcing (Svensson, 2000). Supply chains that are

exposed to risks suffer from poor performance and fail to meet end customer requirements, including availability of products, timely delivery, variety, flexibility and competitive prices (Wagner & Neshat, 2012). These risks also undermine the financial performance of firms that lead to poor sales and ultimately, low profitability. Therefore, researchers are interested in studying supply chain vulnerability to different disasters and the overall resilience of supply chains.

Vulnerability to natural disasters can be studied at different levels, from personal (retailer supply chain) to the societal level (damage to infrastructure and regional economies). Few (2003) observes that most of the research on local vulnerability has focused on developed countries. Therefore, the focus of this research is on developing countries. Further, Wagner and Neshat (2012) have come up with three distinct results from studying supply chain vulnerability. They argue that it is axiomatic that the higher the supply chain vulnerability, the lower the supply chain performance. This performance can be judged by delivery dependability, order fulfillment capacity, delivery speed and customer satisfaction.

Another closely related concept to vulnerability is risk management. Abe and Ye (2013) argue that vulnerability analysis of disruptions can facilitate risk management in an organization. Adams (1995) defines risk as, "a compound measure combining the probability and magnitude of an adverse effect" (p. 8). However, Stenchion (1997) holds that, "risk might be defined as the probability of occurrence of an adverse event but it can be better described as the probability of a hazard contributing to a potential disaster" (p. 5). He further notes that it involves consideration of vulnerability to the hazard. Similarly, Crichton (1999) defines risk as the probability of a loss that depends on three elements: vulnerability, hazard and exposure.

Supply chain risk management is the systematic identification, assessment and quantification of supply chain risks, reducing its bad effects on supply chain performance (POPA, 2013). Jüttner et al. (2003) created a supply chain risk management framework. It explains the sources of risk, risk drivers, risk consequences and four different strategies to manage risks. Although this framework was developed for commercial supply chains, it can also be used to study relief supply chains or business supply chains during periods of disaster. (van Heeringen, 2010)

Recent disasters (the Japanese earthquake, Tsunamis, the Pakistan Floods) have demonstrated that a disruption affecting one entity in a supply chain can badly affect the whole global supply chain. Firms that believe that they have a system to manage risk have

often ignored the critical exposure along their supply chain. Keeping this in mind, Jüttner et al. (2003) have systematically explored the concept of risk management in supply chains. The term 'risk' can be confusing, as it is a multidimensional construct. Sometimes it is referred to as internal or external environmental variables that reduce the output expectedness; in this sense, it is more like risk sources. Other times it is referred to as consequences of risk, similar to operational risks.

The sources of risk are the supply chain, environmental or organizational related variables that have uncertainty in their determination, and these impact on supply chain outcome variables. Environmental risk sources could be the results of an accident, like a fire, socio-political actions and natural disasters. Organizational risk sources are those that can arise from within the organizations, like strikes or IT system failures. Supply chain risk sources can come from the interaction among different actors within the same supply chain (Jüttner et al., 2003). In terms of disaster relief supply chains, environmental risk sources are the natural disasters themselves. These risks create complex situations that directly affect relief supply chains. Natural disasters affect the local population. Hence, labour, communication and transportation will all be disrupted, and that constitutes organizational risk sources. As a disaster occurs, different types of organizations must work together in an integrated form, that, in turn raises supply chain related risk sources (van Heeringen, 2010).

Risk consequences also differ in both commercial and humanitarian supply chains. In commercial supply chains, consequences are related mostly to a reduced customer base and reduced profit margins. Jüttner et al. (2003) identifies five risk drivers, that have increased the level of risk in commercial supply chains in last few years and that directly impact sources of risk. These risk drivers are; focus on efficiency, global supply chains, centralized distribution, increased outsourcing and reduced supplier base. Some of these risk factors are also applicable to relief supply chains. Indeed, in relief supply chains, the focus is to reduce vulnerability of suffering people (Kovács & Spens, 2007). Humanitarian supply chains are often more interested in effectiveness because the lives of people are at risk (Van Wassenhove, 2006). However, there has been a slight shift away from effectiveness to efficiency as donors want more accountability. Humanitarian supply chains (particularly those of large NGOs) are mostly global and centralized. These supply chains typically rely on multiple sources and most of their operations, particularly transportation, is outsourced (Beamon & Balcik, 2008).

Jüttner et al. (2003) introduces four risk mitigation strategies. These are avoidance, control, cooperation and flexibility. Avoidance of geographical markets and specific products are applicable in a commercial context, but in terms of relief supply chains, avoiding food, medicine or shelter is not an option and certainly the affected population cannot avoid the geographic location of the disaster. However, relief providers can avoid certain suppliers who have longer lead times, or who are also vulnerable to disasters (van Heeringen, 2010). Similarly, control strategies in a commercial context involve increased stockpiling and the use of buffer inventories. These strategies can also be used in a humanitarian context through pre-positioning relief supplies in vulnerable areas. In terms of coordination strategies, similar to their commercial cousins, humanitarian supply chains rely heavily on coordination and collaboration among military, NGOs and local retailers. The last strategy of flexibility can be introduced in the humanitarian context by including the concepts of postponement, multiple sourcing and local sourcing (Beamon & Balcik, 2008).

Although Jüttner et al. (2003) have used a risk management framework for supply chains, other scholars note that traditional risk management practices are lacking in their ability to comprehend the complexities of supply chains. These techniques also fail to understand the threat and to prepare an organization for future 'unknowns' (Starr, Newfrock, & Delurey, 2003). Scholars are becoming increasingly aware of the shortcomings of risk management approaches (Pettit et al., 2010), and have pointed to the notion of resilience as a result. In simple terms, resilience can be defined as, "…the capacity of a firm to survive, resist and adapt in the face of turbulent change" (Fiksel, 2006, p. 16). The biggest weakness of risk management is its lack of ability to adequately deal with low probability and high consequences events, the so called 'black swan' events (Kunreuther, 2006). It is expected that the concept of resilience can fill this gap and supplement the extant risk management knowledge to enable supply chains to deal with unforeseen events and create a form of competitive advantage. However, risk management still remains an important part of supply chain resilience. Indeed, basic risk management is identified as the facilitating factor for supply chain resilience (Christopher & Peck, 2004; Park, 2011; Ponomarov, 2012).

2.2.5 Supply Chain Resilience

As noted above, the concept of supply chain resilience emerges as a possible solution to the limitations associated with traditional risk management strategies. It is argued that the

resilience concept provides strategies to deal with disruptions that arise in complex supply chains (Rice & Caniato, 2003; Sheffi, 2015). Indeed, Christopher and Peck (2004) believe that resilience is an essential attribute for supply chains in order to cope with all disruptions.

Timmerman (1981) has defined resilience as the measure of a system to absorb and recover from disastrous events. More comprehensively, the United Nations describes resilience as the capacity of a system, community exposed to disaster to adapt, by resisting or changing to reach an optimum level of functioning and structure (Birkmann, 2006). This is determined by the degree to which societies can organize and learn from past disasters. System capacity is the combination of all the resources, strengths and capabilities available within the organization, community or whole supply chain that can help reduce the effects of a disaster (Ponomarov & Holcomb, 2009).

Resilience is also defined as the ability of a system to bounce back from disturbance (Zakour & Gillespie, 2013). Klibi and Martel (2013) define it as the ability of a supply chain network to avoid or resist the disruptions and to recover quickly from failures (Melnyk, 2014). Other scholars have defined it as the capability of supply chains to anticipate, prepare, respond and recover from disruptions in an efficient and effective way (Ponis & Koronis, 2012; Ponomarov, 2012). Indeed, many resilience concepts are borrowed from other disciplines and is wide ranging concept (Ali et al., 2017). It has its origin in field of ecology, engineering, disaster management and relief supply chains (Haghani & Afshar, 2009), and development psychology (Masten, Cutuli, Herbers, & Reed, 2009). For example, in ecology, resilience can be defined as the ability of a system to survive a disruption and restore its original position, while still maintaining integrity, diversity and processes (Folke et al., 2004). Similarly, resilience in the humanitarian supply chain context emphasizes the different approaches a system can use to respond to a natural disaster. Some definitions emphasize the ability to bounce back from these situations, absorb severe impacts, learn from, adapt to, and recover well from disruptions (Berkes, 2007).

As it is an emerging discipline, there is a great diversity in the definition of supply chain resilience. Some researchers divide resilience into different phases, similar to the disaster management cycles. Most of the literature on supply chain resilience has focused on the response and recovery phases; for example Rice and Caniato (2003) emphasize the ability to respond effectively and recover from disruptions quickly. Similarly, Sheffi and Rice Jr (2005)

also focus on 'bouncing back' from a disaster, or in other words, focused on the recovery phase. At the same time, Gunderson (2000) describes resilience as the capacity of a system to experience distortions but still maintain its control and important functions. Further, Carpenter, Walker, Anderies, and Abel (2001) argue that resilience has two main properties; the first is the amount of change a system can bear while still maintaining its control (structure and functions), and second, is the level to which a system is able to learn and adapt as a response to disruptions (Christopher & Peck, 2004).

Ponomarov and Holcomb (2009) highlight the importance of preparedness in supply chain resilience. Subsequently, many authors emphasize the importance of the anticipation phase (Day et al., 2012; Ponis & Koronis, 2012; Sheffi, 2015). Park (2011) argues that resilience should be an adaptive capability for supply chains to prepare for disastrous situations, respond to and effectively recovering from these situations. This preparedness, response and recovery can be achieved by maintaining the required levels of process continuity, at the desired level of control and connectedness over the supply chain structure. Park (2011) divides supply chain capabilities into readiness capability, response capability and recovery capability. The readiness stage of resilience develops certain capabilities that refers to the coordination of resources to detect and prevent future disruptions in the supply chain (Tukamuhabwa, Stevenson, Busby, & Zorzini, 2015). Response stage capabilities refer primarily to actively dealing with disasters and providing information related to the particular disruption to all supply chain entities. Finally, recovery stage capabilities deal with the interaction among all actors and the sharing of resources to bounce back to normal operations.

In terms of strategies, the extant literature divides resilience mostly into *proactive* and *reactive* resilience, or strategies (Gligor & Holcomb, 2012; Ponomarov & Holcomb, 2009). Proactive strategies are those steps that are taken before a disaster happens, or in the anticipation of a disaster. All of the planning, anticipation and preparation falls into this category (Ambulkar, Blackhurst, & Grawe, 2015). Coping with disruptions or adapting to the new situation comes under reactive strategies (Tukamuhabwa et al., 2015). This is also referred as the strategies that respond to and enable a return to normal, and is sometimes called adaptive resilience (Singh-Peterson & Lawrence, 2014). These two views have been criticized by several scholars who have included a concurrent strategy, or a third form of resilience, in the spectrum from proactive to reactive resilience (Ali et al., 2017). Sheffi and Rice Jr (2005) have discussed concurrent strategies that they see as an initial response to

disruption. It is different than the reactive strategies that deal with recovery aspects more as compared to response. Concurrent strategies are first and initial response capabilities to cope with the disruptions (Sheffi & Rice Jr, 2005). These are also considered to be as rapid adjustments during the response phase of a disaster. On the contrary, reactive strategies take place mostly in the aftermath of a disaster (Hollnagel, 2011).

Another important category that is missing from most of the literature is 'inherent' resilience. This is a type of resilience that is preexisting or inbuilt within supply chains and is *not* a result of any specific resilience actions or planning (Ferris, 2016; Groisman & Ivanov, 2009). Cutter (2016) has reported two similar perspectives of resilience. The first of these is inherent resilience, or the built-in resilience of a system or community, the second is adaptive resilience. This is acquired by the system in the aftermath of the disaster. Inherent strategies or resilience are natural coping skills present in supply chains. These inbuilt attributes of supply chains can help them to resist the negative consequences, thus helping them to respond and recover from the disruption in an effective way (Patterson, 2002).

Figure 2.1 Phases and Dimensions of Resilience

Source: (Ali et al., 2017)

Rose (2006) also divides resilience into the same two types: inherent and adaptive. Inherent means the ability of supply chains under normal circumstances, while adaptive means ability under chaotic situations due to extra effort. He identifies three levels at which resilience can occur. These levels are the individual level, the market level, and the combined

individual/market level. While these levels are from a social system perspectives they can also be applied at the supply chain level as well. Hamel and Valikangas (2003), argue that the main aim of resilience is to develop an organization with the capability to quickly evolve through disruptions without severely affecting that organization. They have stressed the analysis of strength, weaknesses, opportunities and threats because resilience is not just recovery, flexibility or disaster preparedness. As such, Figure 2.1 highlights the phases and dimensions of supply chain resilience.

A slightly different, but equally important view, of supply chain resilience is control, connectedness and coherence dimensions (Reich 2006). Reich contends that it is necessary to include these three principles in disaster management to make individuals or communities more resilient to natural disasters. People or organizations that have more control tend to be more resilient (Gligor & Holcomb, 2012). Control means direction, regulation and coordination of activities. When disaster occurs, individuals lose control over their lives and companies lose control over their supply chains and/or business. In a disaster recovery situation, on occasion individuals may try to regain control, sometimes by looting or vandalizing. Retailers also increase the prices of products or they may supply time expired food (Singh-Peterson & Lawrence, 2014). The negative consequence of helping individuals or organizations are that it tends to create a state of dependency. It undermines individual's or organizations' natural sense of control. Aid agencies and government should devise ways to provide resources or the means to gain personal control. It will make society more resilient (Elliesen, 2002).

The second principle is coherence, that refers to the desire to know and to remove uncertainty. It is crucial to make societies more resilient to disasters. Reich (2006) says that companies should protect the drive for coherence through enhancing meaning, direction and understanding, during periods of disaster. There should be processes and procedures in place to minimize uncertainties and to provide as much information as possible. The primary focus should be clarity about events happening in the area.

The third principle is connectedness. This can be defined as the behavior of people in disasters where they band together, seek out others and establish bonds with strangers. Things get organized and done when people are able to bond with others or work together. More specifically, it refers to the systematic coordination of efforts by different people or organizations to avoid the duplication of services (Ponomarov & Holcomb, 2009).

As well as classifying and categorizing supply chain resilience, existing literature also examines capabilities/elements/components or antecedents of supply chain resilience. Early literature highlighted two main approaches to the study of resilience; the first one is flexibility that involves creating capabilities within the organization or supply chain to respond to disruptions (Christopher & Peck, 2004). This can be achieved by investing in infrastructure and resources. It could involve hiring a multi-skilled workforce, flexible production systems and supplying networks with multiple sources. The second approach focuses on what is commonly called redundancy. Redundancy is maintaining capacity to respond to disruptions in the supply network and can include inventory holdings, dedicated transport fleets and occasionally committing to third-party production capacities (Peck, 2006).

Sheffi and Rice Jr (2005) also argue that flexibility is necessary to achieve resilience. They suggest that instead of just depending on supply chain redundancy, organizations should be flexible which will help to build resilience. Tomlin (2006) differentiates between mitigating and contingency strategies to deal with disruptions. He identifies flexibility as a contingency action which is taken during disasters. Nevertheless, redundancy is a mitigation strategy that is developed in advance of disruption. Christopher and Rutherford (2004) go further and see resilience as depending upon three factors. The first of these is criticality and preparedness. The second factor is situation awareness which can be achieved by a thorough assessment of possible vulnerabilities. The third is adaptive capacity, which is defined as flexibility and agility. Asbjørnslett (2009) treats flexibility or agility as the ability to adjust the current direction to accommodate and adapt successfully to any disruption.

Moving away from redundancy and flexibility, Christopher and Lee (2004) propose that supply chain confidence can be increased by visibility and control. Confidence in the supply chain is one of the best ways to deal with supply chain disruptions. Confidence in the supply chain comes from its ability to recover from adversity. Christopher and Lee (2004) argue that one way to increase control is even management, where pre-determined supply is placed at critical nodes, to manage material flow over the whole network. If some disruption occurs at these nodes, then a warning is sent to all of the supply chain actors to enable corrective actions.

Peck et al. (2003) make an important recommendation, that is, supply chain re-engineering. Conventionally supply chains are designed to minimize costs and take care of their customers. These chains have never taken resilience seriously into account. The report stresses the need

to understand the networks that connect firms to their suppliers and ultimately to their customers. Mapping tools can help identify pinch points and critical paths. Complex network theory and scale free networks provide a way to understand the supply chains networks (Hearnshaw & Wilson, 2013). The following sections will expand the material on complex networks theory. However, for now, pinch points are 'bottle necks,' where there is limited capacity and if these points are inoperable, then the whole supply chain suffers. Critical paths enable actors to find the shortest path from order to delivery. It can also show the single and most important sources that have no alternative. Critical paths can highlight linkages where visibility is poor between nodes (Peck et al., 2003).

According to Abe and Ye (2013), firms (retailers, wholesalers, suppliers) can adopt risk reduction strategies to increase their disaster resilience. Firms should carefully consider the balance between supply chain efficiency and disaster risk preparation. Sourcing from one single supplier can increase profitability, but it makes retailers more vulnerable to disasters (N. Jain et al., 2016). However, multi-sourcing can also increase costs considerably. Firms should hence select suppliers on the basis of risk reduction criteria rather than on pure cost minimization. They can also increase supply chain visibility by monitoring systems and shortening the supply chain. A comprehensive assessment of a company's vulnerability to disruptions and the impact of a disaster on a firm's supply chain can facilitate the establishment of risk transfer and mitigation strategies (Ponomarov & Holcomb, 2009).

Risk management and supply chain orientation are also mentioned as facilitating factors for supply chain resilience (Park, 2011; Ponomarov, 2012). A relational view of the Resource Based theory (discussed in the following sections), as well as Resource Dependence theory, assert that in uncertain times, stronger relationships among organizations allow them to utilize resources from their partners to sustain and survive (Dyer & Singh, 1998). In a supply chain context, having strong and close relationships with suppliers and customers enables a firm to survive the disaster. This strong relationship is only possible if individual organizations recognize the importance of these relationships and the need to avoid purely self-interested behavior. This recognition is called supply chain orientation (Maon et al., 2009; Patel, Azadegan, & Ellram, 2013).

The government (at all levels, national, provincial and district), plays a significant role in risk reduction strategies and achieving resilient supply chains. Kovács and Spens (2011) have

argued that the pre-disaster response (preparedness to increase disaster resilience) is more effective than post disaster response. Here, Governments have a responsibility to incorporate disaster risk reduction strategies into policy development, and to minimize the negative effects of disaster on both communities and supply chains. Governments should have diversified economic structures, efficient energy resources, building codes and ensure proper urban planning. The government should also help small or medium enterprises (SME) by providing them tools to increase their preparedness for disasters and also by promoting disaster insurance coverage (Baez, De la Fuente, & Santos, 2010).

Adaptability should be a key trait in resilient supply chains, as the new state after disruption can be very different from original one (Folke et al., 2010). The dynamic nature of adaptive capability makes it easier for supply chains to bounce back or achieve a more appropriate state after disruption. Other than adaptability, Christopher (2005) reveals that agility and flexibility are key elements of resilient supply chains processes. Based on the work of Cranfield University, Christopher and Peck (2004) have conceptualized supply chain resilience and included elements like, supply base strategy, risk categorization, supply chain risk management culture and collaboration strategies. They also discuss agility, availability, efficiency, redundancy and visibility as secondary factors. Although they provide an interesting point of view, no empirical justification is provided.

Goranson (1999) differentiates between agility and flexibility in planned adaptation strategies for sudden but expected external disruptions. However, agility is a form of unplanned adaptation to unexpected external circumstances. A few authors consider flexibility as part of agility (Stevenson & Spring, 2007). For combating demand and supply uncertainties, H. L. Lee (2004) also suggests supply chain processes need to have agility, adaptability and alignment to achieve superior performance. Agility means responding to short-term changes quickly, to handle external disruptions smoothly. Adjusting the design of the supply chain to meet structural shifts in the market is called adaptability. Alignment means to exchange information and knowledge frequently with supply chain partners to achieve a better performance.

Other authors have also highlighted agility, adaptability and alignment as the main components of supply chain resilience. For example, based on the work of (Reich, 2006) and (Christopher & Peck, 2004), Ponomarov and Holcomb (2009) propose a theoretical model to link logistics capabilities with supply chain resilience. They use a Resource Based View to link

logistic capabilities with supply chain resilience, that can ultimately increase a firm's competitive advantage. They mentioned that a quick response and alignment among supply chain members are important elements of resilience.

Table 2.4 Summary of Key Concepts to Achieve Resiliency in Supply Chains

Concept	Reference	Research Summary
Risk Management	(Christopher & Lee, 2004; Jüttner et al., 2003)	Effective risk management culture is an effective moderator of supply chain resilience.
Agility, effectiveness	(Christopher, 2000, 2005; Christopher & Rutherford, 2004)	Quick response to disastrous situations can be called resilience which is closely associated with the concept of agility.
Flexibility, redundancy	(Goranson, 1999; Peck et al., 2003; Rice & Caniato, 2003)	Flexibility and redundancy have great potential to enable resilience. Redundancy is excess of capacity which can be used to replace the capacity lost during disasters.
Visibility	(Christopher & Peck, 2004)	Increasing visibility on both supply and demand side reduce elements of uncertainty in supply chains.
Supply chain structure and network typologies	(Hearnshaw & Wilson, 2013)	Knowledge of complex supply chain structure and better understanding will surely increase resilience.
Knowledge management	(Pettit et al., 2010)	Knowledge management and learning in periods of disaster are important elements of supply chain resilience.
Reduction of uncertainty	(Berkes, 2007)	Reduction of uncertainty increases supply chain resilience.
Collaboration, coordination	(Ponomarov & Holcomb, 2009)	Risk can be managed more effectively through coordination and collaboration
Reduction of complexity, supply chain reengineering	(Peck et al., 2003)	Complexity of supply chain can be reduced through business process re-engineering to increase resilience.
Adaptability	(Fiksel, 2003; Pettit et al., 2010)	For combating demand and supply uncertainties, supply chain processes need to have agility, adaptability and alignment to achieve superior performance.
Alignment	(H. L. Lee, 2004)	High degree of complexity in supply chains demand an enterprise view with coordination among all business functions within the company as well as inter- organizational alignment among different actors of supply chain.
Contingency planning	(Tomlin, 2006)	Contingency plans are necessary to address risks in supply chain.
Supply base strategy	(Christopher & Peck, 2004)	Single vs. multiple sources and knowledge about supplier's risk awareness are important elements to be considered in building resilience.

Pettit et al. (2010) developed a conceptual framework by combining different dimensions of vulnerabilities and capabilities. They proposed that if vulnerabilities are high compared to capabilities, this will lead to unbalanced resilience, and ultimately excessive risk. Similarly, if vulnerabilities are low in contrast to capabilities then there will still be unbalanced resilience, but it will erode profitability. Balanced resilience can be achieved if the portfolio of vulnerabilities is similar to the pattern of capabilities and this can be portrayed in form of high performance. While Pettit et al. (2010) refined this conceptual framework through focus groups, they did not provide empirical data to support their claims. However, it is clear that adaptability, flexibility, visibility and alignment among processes of supply chain members are the key capabilities in dealing with vulnerabilities as discussed in literature.

Several scholars also mention visibility and velocity as important components or capabilities that increase supply chain resilience (Fiksel, 2006; Jüttner et al., 2003; Melnyk, 2014). Christopher and Peck (2004) combine these two elements into supply chain agility. They define agility as a quick response to disruption. Visibility is defined as the ability to see through the processes of buyers and suppliers. It helps to avoid overreaction and enables effective decision-making processes. (Pettit et al., 2010). Velocity on the other hand focuses on the pace of response and recovery from disruptions (Cozzolino et al., 2012). In comparison to flexibility, velocity put more emphasis on the efficiency of supply chain responses and recovery during and after the disaster (Jüttner & Maklan, 2011). Flexibility is more about the many different possible states a supply chain can have, however, velocity refers to speed of flexible adaptations (Stevenson & Spring, 2009). In terms of resilience, Jüttner and Maklan (2011) & Scholten and Schilder (2015) refer to velocity as the speed with which the supply chain can respond and recover from disruptions. This is quite different from the idea of supply chain velocity that narrowly refers to the speed of inventory flows or turnover in the system.

Adaptability captures the capacity of the supply chain members to learn, adjust responses to the changing environment and continue developing in that new situation (Walker, Holling, Carpenter, & Kinzig, 2004). It is one of the basic components of resilience; resilience is all about coping and adjusting to new situations. Coping can be flexible and also varies from member to member in supply chains (Folke et al., 2010). It is also possible to see adaptation according to degrees of adjustments (Maru, Stafford Smith, Sparrow, Pinho, & Dube, 2014). For minor disruptions, slight adaptation might be effective. However, for major disruptions, a whole new way of doing business might be adopted by the supply chain member (Smit &

Wandel, 2006). Adaptability depends on the resources, knowledge and skills, infrastructure and institutions. While these are important points to consider, there is little empirical research to demonstrate how these elements contribute to adaptability (Smit & Pilifosova, 2003).

Supply chain alignment is also considered to be a key part of resilience as well as disaster management (Pettit et al., 2010; P. H. Tatham & Pettit, 2010). It is the property of the supply chain that helps all supply chain actors align their objectives and interests (Q. Cao & Dowlatshahi, 2005). These objectives could be transparency among actors, profit sharing, information sharing, process re-engineering or risk sharing as examples (Dubey & Gunasekaran, 2016).

From the above literature review, it can be seen that agility, visibility, flexibility, velocity, alignment and adaptability have been the most frequently discussed elements of supply chain resilience. Further, supply chain orientation and risk management are also often mentioned as facilitating factors. Regarding agility, this is a multidimensional concept and researchers have offered a variety of conceptual understandings of supply chain agility. For example, X. Li, Chung, Goldsby, and Holsapple (2008) have defined it as the capability of using resources, both internal and external, to deal with environmental changes in a timely and flexible manner. Costantino, Dotoli, Falagario, Fanti, and Mangini (2012) state that supply chain agility is a network of companies sharing resources and having streamlined processes to deal with crises by focusing on flexibility and quick responses. Aitken, Christopher, and Towill (2002) says that agility is the ability to have supply visibility, flexibility and a quick response in turbulent times. Other than flexibility, velocity and visibility, van Hoek, Harrison, and Christopher (2001) have included reliability in the list of agility components, that is, doing all the right things by delivering the correct product to the correct place for the right people. In this thesis, agility, adaptability and alignment are taken as components/elements of supply chain resilience. Here, however it is argued that agility is further made up of visibility, flexibility, velocity and reliability.

In broad terms, the literature on supply chain resilience is fragmentary and focuses on multiple perspectives of the idea (Christopher & Rutherford, 2004; Park, 2011; Peck et al., 2003; Pettit et al., 2010; Ponomarov & Holcomb, 2009; Sheffi & Rice Jr, 2005). The number of elements that form resilience like agility, redundancy and flexibility tend to be discussed separately (a summary of the related topics is shown in Table 2.4). This thesis attempts to provide a

consolidated conceptual framework to study supply chain resilience. This framework offers a holistic view of different components of supply chain resilience and important supply chain areas discussed in disaster management literature.

2.2.6 Food Supply Chains

Climate change has led to increasingly frequent severe monsoons and cyclones that bring heavy floods in south Asian countries. Similarly, the number of big earthquakes over the last ten years has also increased (Debarati Guha-Sapir & Vos, 2011). Rising temperatures also melt the snow on mountains, often resulting in floods, especially near riverbed areas (Aggarwal, Joshi, Ingram, & Gupta, 2004). These floods can often negatively impact key agricultural lands. Crops are destroyed, infrastructure and transportation are also badly affected. As a result, food prices increase and retailers and other supply chain actors are unable to get supplies on time that in turn affects local communities. Douglas (2009) urges Governments, NGOs, international disaster management organizations and researchers to take action as future disasters will damage transport and communication technologies for longer periods of time and will affect wider areas. This will make the movement of food supplies more difficult. Longer wet periods will also affect the storage of food, unless particular care can be taken.

Several studies examine food supply chains in general (Acharyulu & Mathew, 2006; Burch & Lawrence, 2007; Campbell & MacRae, 2013; Farhat, 2012), both in developed and under developed countries. However, very few of these studies have discussed these supply chains in the context of resilience of the private sector (Dani & Deep, 2010; Leat & Revoredo-Giha, 2013; Vlajic, Van der Vorst, & Haijema, 2012). Even fewer have investigated them in the context of natural disasters, and those that do typically focus on developed countries (Keogh et al., 2011; Singh-Peterson & Lawrence, 2014).

Paavola and Adger (2002) divide disaster response and adaptation into four different levels: international, national, local and individual levels. Responses to disasters can be based on the uncoordinated actions of individuals, companies and organizations or a collective action at local, national and international level. So far, proactive action is mostly focused on international and national levels. There has been little research done on local and individual adaptive responses. Most South Asian countries have systems in place for sourcing and encouraging international food aid. They have standing emergency relief systems for distributing food to affected areas. However, at the local level, the government distribution

channels are not effective. Douglas (2009) has highlighted the proactive, reactive and inaction responses to the floods in South Asia, at international, national, local and individual levels in the following table.

Material removed due to copyright compliance.

Source: (Douglas, 2009)

Food supply chains are very fragmented and complex in South Asian countries (Kalidas, Jiji, & Sureka, 2014). Rapid responses to disasters can be hampered because this complexity makes these supply chains highly vulnerable when communications and transport are disrupted by disasters. Acharyulu and Mathew (2006) assess these flows as 'disjointed' supply chains. On average, food passes through six middlemen before reaching end customers that often result in higher prices and poor quality food (Acharyulu & Mathew, 2006).

Floods and earthquakes often destroy local infrastructure, including roads that hinders transportation services in the area (Kovács & Spens, 2011). In this situation, McKinnon (2004)

states that grocery retailers will be the most affected, followed by the fuel supply chain, banking and postal services. Groceries would be highly affected due of the high volume of throughput and highly time-sensitive deliveries. Fresh milk, bread, eggs, fresh meat and vegetables will be depleted within hours. Fast moving canned products will also be replenished at almost the same rate. Companies have more stock of these ambient products, but they will not be able to move them to point of sale. Even after the road network has resumed working, it will take some time to refill grocery stocking levels to normal because of capacity limitations at the production, handling and transport levels. This will increase the recovery time of supply chains that have an indirect impact on individuals, industries and local communities.

Beulens, Broens, Folstar, and Hofstede (2005) have presented a framework for the design of food supply chains, which enables them to be effective and efficient. According to the authors, supply chain networks exist if they have four essential features.

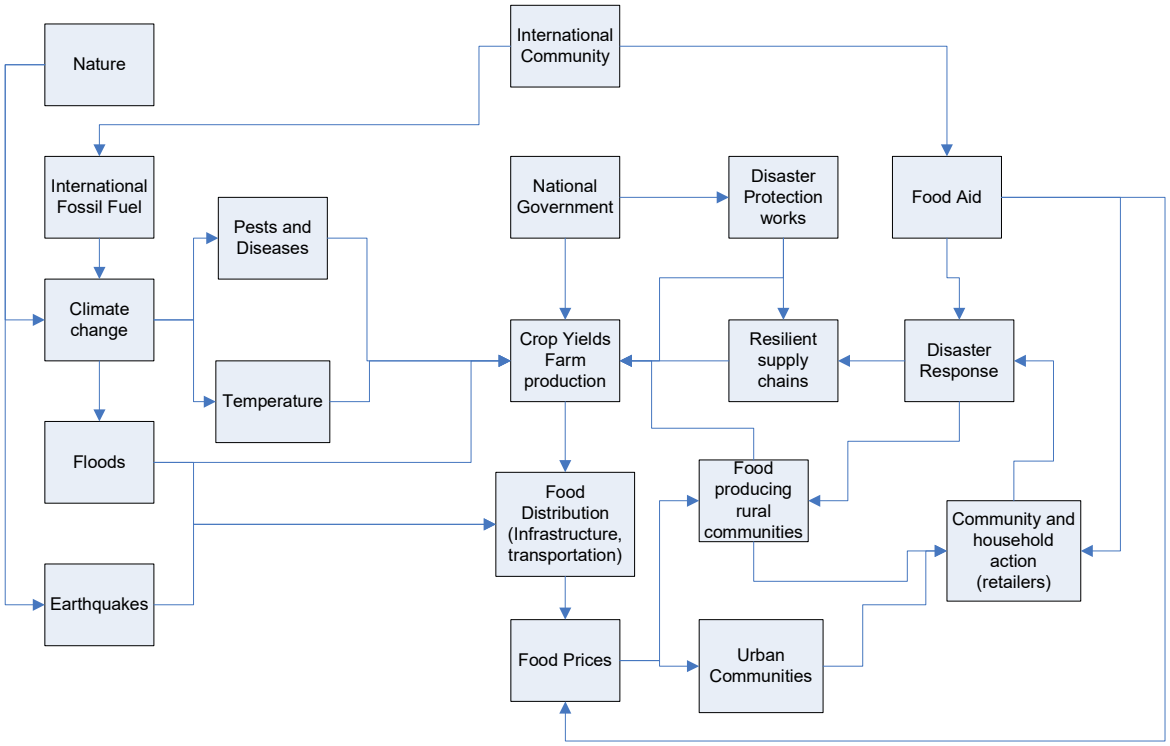
- Structure: who are the different actors and what sort of relationship do they have
- Process: this defines whether the tasks to be performed are identified and recognized with transparency (and what is level of integration between these tasks?).
- Resources: infrastructure, warehouses, human resources, machinery, transport, vehicle systems: their ownership and availability to the supply chain.
- Management: defines different stakeholder of these supply chains who coordinate these chains and networks (what are their objectives and responsibilities?).

Out of these four, 'resources' require a special mention. Food supply chains depend on people who help in food movement and management. These chains depend heavily on machines, vehicles, containers and tools that make movement possible. Proper infrastructure is another resource that contributes to the success of these supply chains. Warehouses provide critical value to the logistics processes of food supply chains. They provide storage, stocking for delivery, packaging, sorting and help in making movement and distribution possible (Beulens et al., 2005).

As noted earlier this thesis argues that commercial food supply chains also face similar problems to relief supply chains during periods of disasters. In relief supply chains, four logistic

related processes are very important. These include facility location (that is, finding a suitable position for holding inventory), transportation decisions, inventory management and distribution decisions (Roy et al., 2012). Inventory management decisions includes the type of inventory and inventory policy decisions (Beamon & Kotleba, 2006). Inventory types mean what inventory is store in different facilities (Lodree Jr, 2011). Inventory policy includes target inventory levels: minimum and maximum inventory levels for each important food item; order quantity and stock replenishment policies (Chopra & Meindl, 2007). For effective and efficient supply chains, these four functions need to be integrated. This will also make these supply chains more resilient to turbulence. Indeed, how local food supply chains deal with these functions is yet to be examined in the literature and particularly in relation to the South Asian context. Figure 2.2 highlights the interaction of food supply chains at different levels.

Figure 2.2 Schematic View of How Food Supply Chain Interacts at Different Levels



Source: Developed by Author

To improve disaster responses, especially in context of food supply chains, Douglas (2009) contends that strengthening local community resilience is very important. Resilience can be achieved through ensuring local food stocks and shelter, by supporting local community groups and working with local governments. Aggarwal et al. (2004) argues that strategies to reduce the vulnerability of local food supply chains to disasters must be based on technical

and policy combinations. To achieve these goals, one should have a deeper understanding of how the local food supply chain works in practice and how these supply chains interact with the local community. In addition, one must also understand how these food supply chains also interact with humanitarian supply chains.

There are generally considered to be two types of food supply chains based on their geographic lengths: typically long (global) and short (local) food supply chains (Singh-Peterson & Lawrence, 2014). Long-supply chains tend to be operated by large retailers where these stores depend on sourcing from international companies. They tend to have large warehouses and food has to travel approximately 1,500 kilometers before reaching its target market. In contrast, short or local food supply chains tend to depend on a few local sources and have close relationships with the local community (Singh-Peterson & Lawrence, 2014). This thesis contends that food supply chains should not be categorized based on their length, as it is impossible to determine the cut-off points for long and short distances. Instead, this thesis adopts the protocol of calling these local chains (those residing within a specific region/area) or international supply chains where supplies are moved across borders.

Kneafsey et al. (2013) argues that a local food system is one where food is produced, supplied and sold within a defined geographical area. Food which travels within local food systems is usually traceable to a particular source of origin and has distinctive characteristics. Local is always understood in relation to the larger geographical area (that is, regional, national or international). However, where the local area ends is a highly subjective matter. Some supermarkets that operate at national and international levels often describe the whole area as local. Sometimes food is generated and produced at one location but sent hundreds of kilometers away for packaging or processing before returning to the original location for sale. This can also be called local food in the sense that it is produced and consumed locally.

Singh-Peterson and Lawrence (2014) argue that local supply chains are more resilient to disruptions than longer chains. There is also some evidence that consumers prefer local food producers as compared to supermarkets in times of disaster. There are number of reasons why consumers might prefer local food retailers, indeed, a primary reason relates to the freshness of food (Conner, Montri, Montri, & Hamm, 2009; Grebitus, Lusk, & Nayga Jr, 2013; A. R. Hunt, 2007). Conversely, Peck (2006) claims that large retailer supply chains are less vulnerable to disruptions as their networks can better withstand the loss of any store or

supplier without a major disruption. Large retailers often look to their suppliers to provide cover as a contingency plan. They expect their suppliers to hold redundant capacity and stock. They also want their suppliers to provide logistical flexibility to meet emergency demands when required. In contrast, small retailers depend heavily on their wholesalers for supply chain continuity (Peck, 2006).

2.2.7 Community Resilience

Moore, Eng, and Daniel (2003) note that it is mostly community-based organizations who provide the first line of relief when disaster strikes and are often neglected in emergency management planning. Yet strengthening these organisations is now emerging as new trend in academic research (Duran, Ergun, Keskinocak, & Swann, 2013; Jahre & Jensen, 2010; Van Wassenhove, 2006).

In the case of emergency events, community resilience can be enhanced by community coordination that requires proper communication and disaster response planning. Kapucu (2008) studied the four Florida hurricanes of 2004 to assess the community response to these emergency events. The findings suggest that pre-disaster planning, effective communication between emergency managers and local authorities, and the use of technology all had a major impact on the community response. Retailers made an extra effort to provide the local community with supplies, that demonstrates that retailers can play a significant role in local community resilience. While Kapucu (2008) makes some interesting points, he does not discuss exactly how retailers can contribute to community resilience, nor does he explain how retailers can make sure their own supply chains are resilient.

The ability to respond to a community suffering from a natural disaster is determined by the social structure and processes already in place (Pelling, 2003). Managing a community response is a big problem for government officials who must plan for such events. However, when catastrophic events are ongoing and occur on a relatively frequent basis, governments and communities may be underprepared, but have greater opportunity to plan.

Improving community resilience helps to reduce vulnerability during periods of disaster. In their studies, López-Marrero and Tschakert (2011) summarize the points required for enhancing resilience in the flood prone area of Puerto Rico. Resilience enhancement in these communities require the promotion of effective collaboration between emergency managers and local community members, stressing the importance of developing a proper disaster

management framework and support for social cumulative learning based on previous disaster knowledge. Here local community means mostly local government members and individuals households (Berkes & Ross, 2013).

At the same time, local food supply chains and their actors can also be part of local communities that can also enhance overall community resilience. This can be done through trustworthy collaboration with international and national humanitarian organizations, and by making their own supply chain more resilient to disruptions. In Africa, Iraq and Pakistan food aid agencies have tried giving cash vouchers to local people, who can claim food from local retailers using this voucher. Retailers can claim their money from humanitarian organizations at a later date (Doocy et al., 2011; Heltberg, 2007). This cash giving strategy puts even great demands on local food supply chains and requires greater levels of resilience.

Guarnizo (1992) has noted the importance of adjustment mechanisms in community resilience to natural disasters. He says that communities develop certain adjustment mechanisms by making mistakes and learning from these mistakes over a period. He developed these mechanisms after studying community relationships within the larger environment; the economic, social and political processes of development. At the same time, the study of the emergency event is equally important to understand these adjustment mechanisms. Gurnizo (1992) developed a simple framework with four categories of adjustment (social organization, economic relations, technology use and cultural arrangements) and three phases of disaster life cycle (prevention, response, recovery) (Kovács & Spens, 2007). The idea is to list different adjustment factors in any community to better deal with different phases of a disaster (see Table 2.6).

Table 2.6 Disaster Related Adjustment Mechanisms.

Material removed due to copyright compliance.

Source: (Guarnizo, 1992)

The disaster life cycle here is the same used by other authors (Kovács & Spens, 2007; Van Wassenhove, 2006). Every disaster management cycle can be divided into at least three phases. In each phase, certain functions are performed by different people in the community, and this varies from community to community. The important thing in this framework is the adjustment mechanisms. These mechanisms are different for each phase of disaster. In social organizations, the most important mechanism to deal with disaster is the family. Extended family relationships provide a network for mutual assistant to cope with the stress of the disaster. Mutual aid and self-help groups are other important adjustment mechanisms in this category (Guarnizo, 1992). Subsequently, local retailers and local food supply chains could also be important social/economic adjustment factors (Singh-Peterson & Lawrence, 2014).

There are many adjustments factors included under the category of economic relationships. Rural individuals adopt different risk aversion/avoidance mechanisms, like the diversification of crops, different storage schemes and switching to nonagricultural activities during times of disaster. Communities also develop marketing strategies and trade linkages with regional markets to access alternative sources of income. Banks and other financial institutions also decrease interest rates on loans during the recovery phase for house rebuilding activities (Tomasini & Wassenhove, 2009).

Similarly, communities use technology to adjust during times of disasters. They use new methods of employment of soil and solar energy to run 'tube' wells and the latest storage techniques to store food. There are also cultural mechanisms, behaviors, and beliefs to cope and adapt to disasters. Obviously, different societies perceive disasters in different ways. They use unique knowledge sharing techniques to pass knowledge and lessons learned to the next generation (Guarnizo, 1992).

Within one community, both humanitarian organizations and private sectors often work side-by- side to provide relief to local community. Zyck and Armstrong (2014) have introduced different forms of engagement between private sector and humanitarian organizations. They highlight different barriers to engagements and proposed opportunities for both of these sectors. However, their work is only limited to Jordan and focuses specifically on the refugee camps there. Discussing the collaboration between these two sectors, they argue that private sector organizations can act as relief donors, yet cash and in-kind donations are rare in Jordan.

Sometimes, private sector firms, provide goods and services to relief agencies, either as a charitable act, or commercially. The business community can also help by providing goods and services to the local people (Horwitz, 2009b).

Although there are a number of opportunities for both the private sector and humanitarian sector to collaborate with each other, there are number of barriers that impede these efforts. Zyck and Armstrong (2014) had identified the following barriers:

- Humanitarian and private sector organization know little about each other's capabilities, expectations and needs.

- Relief agencies see the private sector as profit-minded organizations. Business managers may think that relief agencies are wasteful and ineffective in the local conditions.

- There are also organizational and procedural barriers. Most relief providers do not seem interested in collaborating with the private sector. Private organizations who try to contact aid agencies feel that decisions are delayed, and, in many cases, decision making is vague. Business managers sometimes do not know whom to contact.

- There is a lack of common forums or other ready opportunities through which both sectors can connect and share information.

Lindell, Prater, and Perry (2006) present a learning perspective of resilience that deals with the recovery phase of disasters. They suggest that disaster resilient organizations, communities and individuals learn from their experience and support sustainable development policies. For example, the resilience of infrastructure could be increased in the recovery phase (such as building a new bridge with a better design). Likewise, talking about the community resilience, Berkes (2007) reports different elements that can support community resilience during natural disasters, such as learning from disasters, flexibility and building networks through knowledge sharing.

One important element that jeopardizes local community resilience is food aid dependence. While criticizing humanitarian organizations who provide food relief, Kripke (2005) argues that although the disaster occurrence ratio is increasing in the world, a large amount of (food) aid resources are wasted due to inefficiency, poor forecasting, poor targeting and policy

obstacles. Food aid is often not provided at the right time/place/people. In most emergency situations, food cannot reach the right target because of delivery delays at the ports, as well as a mismatch between recipient needs and the food items donated. Indeed, aid dependence potentially weakens the quality of the local community/governing bodies and public sector organizations by weakening accountability, and encouraging corruption, instigating conflict over the control of aid funds and alleviating the pressure to reform inefficient policies (Knack, 2001).

Elliesen (2002) has also found that food aid limits the will for self-help. Different actors in food supply chains become dependent on aid and the drive to help oneself slowly diminishes. Food aid can destroy the local market if prices fall so much so that does not cover farmers' costs, or alternatively, the prices paid for local food by aid agencies creates high levels of inflation. Often actors use food aid or humanitarian relief items for their personal agendas. Politicians use food aid or other items as a gift for the people, buying legitimacy. Transport firms also pressurize the government to continue moving aid because of the large profits in transporting relief on behalf of the donors (Kripke, 2005). As all these factors all impact on the local economy and community, Elliesen (2002) calls for better utilization of local resources and enhancing the local capacity to handle emergency situations.

Stewart (1998) reveals the factors that result in dependence on food aid. Humanitarian organizations often fail to achieve their objectives due to misunderstanding the real problems people face and the strategies they adopt in the face of conflict and food shortages. Complex coping strategies need to be investigated first. Helping sustain local food prices is often a much better strategy then food aid itself (Levinsohn & McMillan, 2007). Local retailers and service providers are more familiar with micro and macro conditions of the affected area than humanitarian companies. Humanitarian organizations should thus develop good relationships with local actors as this will encourage food supply chain resilience for both parties.

2.3 Theory Base

A range of theories can be used as theoretical lens to study supply chains. Multidisciplinary approaches drawn from areas such as strategic management, socio-political economics, economics, networking and engineering (Ponomarov, 2012) are common. The purpose of this research is to understand the supply chain capabilities of food supply networks. In particular, this thesis is interested in the social relationships among different supply network actors. A

key purpose of this thesis is to design a robust theoretical base as good research is always grounded in theory (Clifford Defee, Williams, Randall, & Thomas, 2010). As research in supply chain management is still evolving, using multiple theories provides valuable insights and understanding into the phenomenon.

This literature review has covered a range of theories. Two important theories that can be used to look at the themes of supply chain resilience and supply chain capabilities are network theory (NT) and relational view of resource-based theory (RBT). Along with disaster management and supply chain resilience literature, these two main theories are used to frame the findings. Two other supporting theories are also used; social capital theory and coopetition. These theories have been relatively underutilized in studying supply networks but offer different perspectives to understand these issues. Each lens employed here is aligned with key features of the literature review (please see Table 2.7).

Table 2.7 Association of Literature with Theoretical Lenses

Lens	Association with the Literature
Network Theory	Relationships, flow of products, collaboration, coordination, knowledge management, supply networks
Resource Based Theory	Agility, flexibility, robustness, alignment, adaptability, supply chain capabilities, firm resources
Coopetition	Collaboration, coordination, competition, resources
Social Capital	Collaboration, social networks

Source: Developed by the Author

2.3.1 Network Theory

Food production and distribution is a multi-firm process. It is also not a linear process as food supply chains can be thought of as complex organizations. The expertise and performance of each actor involved is important and these actors are dependent on each other's performance to run their businesses. A such, these actors and their relationships form a large web termed as a network (Håkansson & Ford, 2002). Fundamentally, network theory examines the methods and processes that interact with network structures to produce certain results for individual actors or groups and also to understand the behavior of the network as a whole (Barabási, 2009). Network theory considers these structures as purposefully interconnected. These interrelated entities can be a single firm, a dyad or a triad (G. Li et al., 2010). A triad is the smallest unit of a network (Choi & Wu, 2009). Most of the early research on networks is from an individual perspective (Merton, 1957). Recently, however, scholars have begun to

study triads in networks (Hearnshaw & Wilson, 2013; Pathak et al., 2007; Pathak, Wu, & Johnston, 2014).

2.3.1.1 Basic Elements of Network Theory

Scholars use this network theory to understand the structure and connections among individual actors, dyads and triads. In the case of supply chains, at a very basic level, two types of network can be recognized depending on the characteristics of the nodes and the nature of the links; an actors' network and a physical network. The actor level consists of the firms that operate and work together in a given environment. These firms exchange goods, information, knowledge and money (the links). The physical network comprises of warehouses and other storage places which can be accessed by different forms of transport. Together these networks make a supply network.

A network consists of two main elements: nodes and arcs/links. Different nodes are connected together through the arc. Nodes are also called points or vertices and arcs are also called ties and edges. Nodes represent the actors, whereas the arc is the relationship between them. How the nodes are interlinked through arcs defines the structure of any network. Network will be called a complete network if all the nodes are connected to each other. Nodes can be directly connected to another node or they can be indirectly connected through other nodes and arcs. Any limited sequence of nodes and arcs is called a walk and if each node is unique on this walk, it will be called a path. In one network, multiple paths can be present and on each path, the flow of goods, money and information may differ (Wasserman & Faust, 1994).

The interpersonal links and ties among different firms are called social networks. Social capital is a vital intangible asset which can increase the overall efficiency of the supply network (Krause, Handfield, & Tyler, 2007). Social capital covers issues of trust, rules, norms and beliefs that are part of any society. These networks influence the way firms perform in a given context. Firms are embedded in these networks and the degree of embedding decides the relationship with other firms in the same network. This aspect of network theory can be analyzed using social capital theory. Social capital affects firm performance and relationships (Johnson, Elliott, & Drake, 2013). It is different from physical resources, as it is not located at a certain place, but rather, is embedded in relationships (Wills-Johnson, 2008). Social capital can be defined as all the available resources within a network and that are derived from the relationships between different firms or individuals (Nahapiet & Ghoshal, 1998).

Network perspective is important for the study of supply chains as it provides a way to understand the structural characteristics of ties, collaboration and also the power distribution in various organizations. Choi and Wu (2009) view a supply network as a network of organizations engaged together in producing and distributing products. Specifically, they underscore the importance of dynamism in these networks. These networks are not static in nature, but rather, are ever evolving as they are affected by numerous events (disasters included). These supply networks adapt, as organizations try to adjust their position in order to survive and fulfill the demand of customers in these events (Pathak et al., 2007). As mentioned before, triads are the smallest unit within networks (Dubois & Fredriksson, 2008). To understand supply networks, it is necessary to understand the relational actions between different triads. Simmel (1950), a pioneer in the field, discussed triads in a sociological context. Later on, Burt and Celotto (1992) studied the behaviors of nodes in various social contexts. In any network, two nodes may have no direct link, but through the third node which is common to these two. The third nodes play the role of a broker and this disconnection is called a structural hole (Burt & Celotto, 1992). The two disconnected nodes may be aware of each other but do not form any relationship with each other. This triadic block can have two separate relational strategies. One is '*tertius gaudens*' as introduced by Simmel (1950), that means a third party benefits from conflict between two others. In this strategy, the third node controls the two nodes by actively separating them, thus deliberately creating a structural hole. However, there is another relational strategy which may be present between two nodes which is called '*tertius iungens*'. This term means the third party unites the other two. In this strategy, a buyer forms a bond a between two of his/her suppliers thus increasing collaboration within the network (Wilhelm, 2011).

Based on these two main relational strategies, Obstfeld (2005) shows the evolution of social networks (Figure 2.3). Where A is a primary buyer, B and C are first-tier suppliers, D, E, F, G are second-tier suppliers. Similarly, this can be seen in the case of natural disasters where, in the response and recovery phases, new ties evolve (or break) within the network.

Figure 2.3 An Example of an Evolving Triadic Network.

Source: Adapted From (Obstfeld, 2005)

Key actors in these structures control and coordinate to ensure that customer demand is fulfilled (Choi & Krause, 2006). Based on this perspective, Pathak et al. (2014) introduced four elements in supply networks that are interrelated and are common to each network: firm level activities, ties among firms, network level goals and network governance. Firm level activities include, the routine tasks performed by a firm such as procurement, product packaging, product development and distribution. Ties refers to the coordination among different firms to achieve the daily operational objectives of individual firms, that ultimately fulfils the network level objective to collectively deliver the products to end customers (Batt & Purchase, 2004). Governance refers to controlling and managing the behavior of individuals or group of actors, present in the network. (Provan & Kenis, 2008) argue that there are three ways by which this can be managed: shared (where individual firms present in the network govern accumulatively), lead (where one single lead firm controls and manages the network) and network administered (some separate entity or governing body manages the network). These factors refer to the governance or the administration of the network, however networks have inherent properties themselves. Indeed, supply networks will be efficient if overall coordination and governance is satisfactory throughout the network. There are three main properties that are evident in efficient supply networks, these are: short characteristic path length, existence of power law distribution and high clustering coefficient. This being true for scale free networks (Barabási, 2009; Ramasco, Dorogovtsev, & Pastor-Satorras, 2004).

Discussing these three properties in turn, the characteristics path length points to the average detachment between two random nodes selected from a network. In terms of the supply chain, it depicts an average number of firms from all of the tiers that must be traversed

between two randomly selected nodes. If a large number of intermediaries are involved, then the average length from the initial supplier to the end customers will be obviously high. An efficient supply chain will have a short path length: in short, there will be a smaller number of traverses between the two nodes (Hearnshaw & Wilson, 2013). This short characteristics path length demonstrates the small world property originally coined by Milgram (1967).

Next, the clustering coefficient refers to the probability of two suppliers of a given buyer as being attached to each other (see triadic structural holes definition above). It is necessary to examine these different triadic relationships in any network. A high clustering coefficient means there are more (triadic) links between contiguous nodes, potentially more collaboration, and hence more efficiency at a network level (Pathak et al., 2014).

Finally, the Power law distribution means that there are only a few nodes in the network with the highest number of connections present. These are generally referred to as 'hub' firms (Barabási, 2009). Human and Provan (2000) state that the presence of a hub firm in a supply chain network is significant. Like the channel leader, these firms tend to control and manage the network wide coordination of supply chains. It should be noted that only 'scale free' networks possess a Power law distribution. Other distributions may reflect other network structures, yet it is not necessary for a Power law to be present to establish the presence of hub nodes.

Traditionally, networks are modeled as either regular or random. Today, there are typically a large numbers of actors involved in supply chains and thus their complexity has subsequently increased. This is why, Choi and Krause (2006); Hearnshaw and Wilson (2013); Pathak et al. (2007) assert that the supply chain should not be considered as a simple system, but rather, as a complex adaptive system. Hearnshaw and Wilson (2013) believe that complex network models capture the properties of efficient supply chains in a more holistic-systems way.

Two common and important complex network models are the Watts-Strogatz's (WS) model and the Barabasi- Albert (BA) model. Based on the random network typology, the WS model suggested that high clustering coefficients and the 'small world' properties better represents the efficient network (Watts & Strogatz, 1998). But random connections is not an accurate depiction of the formation of various supply chain relationships developed in real supply chains. It means that supply chain are systems with a fixed number of firms and relationships (Hearnshaw & Wilson, 2013). Indeed, the BA model provides an alternative, a scale free

network, that deals with supply chain complexity. In comparison to the random attachment model, where pairs of nodes are randomly connected to each other, scale free networks evolve through the mechanism of preferential attachment. That is, new nodes entering the network will 'choose' those nodes that already have a high number of connections. In reality, this mechanism produces a 'rich-gets-richer' phenomenon (Besanko, Dranove, Shanley, & Schaefer, 2009). This formation mechanism helps explain the existence of hub firms in the network and is a unique feature as compared to other models.

Scale free networks demonstrate an amazing robustness and resilience against any random disruption (Hearnshaw & Wilson, 2013). This property is embedded in their inhomogeneous topology, in that, the removal of small nodes (that are plentiful) in the event of some disaster would not affect greatly the overall network. Hence, the network will keep on working or will return to the same state as it was before the disaster. This is because the majority of the links are associated with the hub firms (Albert, Jeong, & Barabási, 2000). However, if there is a planned attack on the hub, then the whole network would become vulnerable to this threat. This is an inherent drawback of these types of networks based on hub firms.

Another important element of resilience is adaptability. Researchers have revealed the relationship between adaptability, size of the network and persistence (Palla, Barabási, & Vicsek, 2007). Smaller networks are more adaptable and persistent when they have fixed and stable hub firms. In contrast, larger network tend to be adaptable, particularly if new nodes are constantly entering and exiting the hub node (Cowan & Jonard, 2007). For achieving resilience and adaptability, firms need to contrive and position themselves in these networks to access information and resources. These resources, and any competitive advantage through these, can be explained with the help of resource-based theory.

2.3.2 Resource Based View

The resource based view, that is also known as the resource based theory (RBT) (Barney et al., 2001; Hart, 1995; Kogut & Zander, 1992), is a theory that is widely used in the management discipline. It is used primarily to explain the unique resources that a firm uses to achieve a competitive advantage (Barney, 1991). This theory has been applied extensively to supply chain research in the past (Barratt & Oke, 2007; Ponomarov, 2012).

The key components of RBT are the resources, capabilities and strategic assets of a firm (Barney, 1991). Firms can achieve competitive advantage by exploiting their strategic

resources, and focusing on internal processes and capabilities (Wills-Johnson, 2008). Firm resources can be physical capital such as technology, raw materials and other tools available. They can also include human capital such as manpower, relationships, intelligence, and experience as examples. Additionally, it can include organizational capital like planning, control or reporting structures (Barney et al., 2001). These resources can be divided into tangible items (physical equipment) and intangible ones (relationships) (Lisboa, Skarmeas, & Lages, 2011). There are four sources through which these resources can be developed (Wills-Johnson, 2008). The first one is tacit sources that are skills dependent and people intensive. The second category of sources are socially complex including relationships among firms, reputation and customers. The third set are related to history and legal property rights and the last one is embeddedness, that comes through social capital (firm culture and principles) (Russo & Fouts, 1997).

Another stream of resource based theory, dynamic capabilities (Teece, Pisano, & Shuen, 1997), emphasizes the dynamics and organizational ability to develop resources dynamically in order to achieve competitive advantage (Helfat & Peteraf, 2003; Ozcan & Eisenhardt, 2009). These researchers contend that in order to deal with the changing environment, firms need to reconfigure, build and integrate both internal and external competencies (Wu, 2010). Therefore, dynamic capability are resource capabilities that can be extended and modified, depending on the dynamics of the industry in which the firm is embedded. This dynamic view suggests that firms need to have access to external resources that can be acquired through relationships with other organizations in the industry.

This suggests that firms acquire capabilities by utilizing network resources, such as intangible resources, generated through supplier relationships (Barney et al., 2001). This view is called relational based view of RBT. It contributes knowledge by explaining why firms establish relationship ties and collaborate with other firms to gain a competitive advantage (Dyer & Singh, 1998). Similarly, if these group of firms are considered as a network, then, in line with the relational view, these important resources can be owned by suppliers, customers and other stakeholders. Thus, they can be accessed and utilized through the network ties (Fjeldstad & Sasson, 2010).

These network resources open up new opportunities for firms, for example, they can leverage more market capabilities and thus reduce the impact of uncertainties. These shared resources

often initiate and help innovation (Baum, Calabrese, & Silverman, 2000; Slater & Mohr, 2006). Subsequently, firms can enhance performance and learning by sharing tacit and explicit knowledge among different ties in the network. This reduces spending on research and development as information is readily available and ultimately helps in effective risk management (Gulati, 1999).

However, organizations present in the network do not have uniform access to utilize these resources. These interactions between nodes are difficult to manage, which often leads to failure or very low success rates (Kale & Singh, 2007). Relational skills and partner knowledge are key network capabilities that help achieve a balance between learning from partners, as well as protecting the firm's own specific capabilities (Kale, Singh, & Perlmutter, 2000). A relationship/network view is useful for further exploring the possibilities of developing capabilities and for managing so called 'coopetitive' relationships within the network. However, to balance the coopetition capability within a network, additional capabilities may also be required (Johansson, 2012).

2.3.3 Coopetition

Originating from game theory, the concept of coopetition (simultaneous cooperation and competition) has been generally adopted by the business community (Lado, Boyd, & Hanlon, 1997). Barry, Adam, and Agus (1996) introduced this concept in management when they coined a term that attempted to capture the simultaneous behavior of both competition and collaboration by the same actors, and between exchange actors. Similarly, Lado et al. (1997) argue that this term can be conceptualized as having elements of both cooperation and competition, rather than seeing these two terms as two extremes of a continuum. Strategic management scholars describe coopetition as rent seeking behavior with high versus low cooperation and competition (Bengtsson et al., 2010b). Rent seeking behavior points towards an organization's search of resources that enhance their value. Bengtsson and Kock (2000) note that depending on the industry, as well as resources needed, firms within the industry can have four relational approaches: competition, co-existence, cooperation or coopetition. They present a narrower picture of coopetition, as having cooperation in some activities, but not in others. This focuses on behaviors, rather than firms, and can explain the dynamics of coopetition in a better way.

Recent research on coopetition has examined the drivers, dynamics and outcome of this capability (Gnyawali & Park, 2009; Peng, Pike, Yang, & Roos, 2012). The drivers of coopetition are divided into structural and contextual reasons. Besides these, firms' motives play an important role in collaborating with competitors. In the event of disasters, network dynamics push companies to collaborate with their competitors in order to survive and thrive in intense conditions (Gnyawali & Park, 2009; M. M. Wilson & Meriläinen, 2014). Similarly, a firms' embeddedness within the network, their own strategies and capabilities, urge them to participate in coopetition. The reasons to engage in collaboration with their rivals are many, and in terms of disasters, mostly relate to the overall survival of the network. Firms share risks and knowledge to stay alive in the midst or aftermath of the disaster. High levels of trust and commitment with win-win scenarios are needed to enable these types of relationships with often fierce competitors (Dyer & Singh, 1998).

Different manifestations of coopetition exist in the literature. Some include, intentional verses unintentional coopetition, similarly dyadic and network level coopetition, and procedural versus structural coopetition (Kylänen & Rusko, 2011; Okura, 2007). Normally, coopetition is considered to be intentional or planned coordination between two competitors. However, legislation of different countries can restrict collaboration between competitors in any one industry. There are different types of coopetition observed within supply chain hierarchies (Okura, 2007). Mostly, collaboration exists in the upstream part of the supply chain and more competition is seen in the downstream side. (Wilhelm, 2011).

There are other instances where unintentional or emergent coopetition has been observed. In natural disasters, or in turbulent times, organizations tend to help each because they consider it a form of social responsibility (or a way to survive). The government and other public sector organizations play an important role in facilitating these relations (Kylänen & Rusko, 2011). The interaction among organizations within a network could be competitive and collaborative at a horizontal level as well as a vertical one. At a horizontal level, this interaction would be between to competitors. Therefore, competition is inherent. However, in adverse conditions, collaboration has also been observed (Pathak et al., 2014). On the contrary, at a vertical level buyers and suppliers could compete for technology, knowledge or resources as well as mitigating the threat of being vertically integrated. Similarly, they can engage in collaboration in order to facilitate the flow of information and supplies (Choi & Wu, 2009). If the coopetition is present exclusively between two competing firms then it can be thought of

as dyadic coopetition (Ritala, Golnam, & Wegmann, 2014). Yet, coopetition in supply chain management is discussed primarily in terms of multiple sourcing or parallel sourcing. Here, the relationships are considered triadic (where buyers force a relationship between two suppliers). Supply network researchers have argued that dyadic relationships can describe the node interaction in a network but that they fail to clarify how the node ties effect other relationships in the network (Choi & Wu, 2009).

2.3.4 Social Capital Theory

Working in a group with mutual trust, respect and coordination makes it easier to achieve complex common targets. These targets are otherwise difficult to achieve when working alone. Human beings have an inbuilt quality of attempting to develop synergy when they perform a certain task in a group (Leonard & Onyx, 2004). This phenomenon can be referred as the special attribute of social structure that is valuable for the members of the society as an important resource. This concept has been termed 'social capital' (Aldrich, 2011; Nahapiet & Ghoshal, 1998).

Putnam (2001) defines it as the features of social actors or organization such as networks, values and trust that promotes cooperation among the actors for mutual benefit. Similarly, many other authors have defined it as the social relationships present among social actors, which naturally assist or encourage the attainment of skills and values in the marketplace (Boxman, De Graaf, & Flap, 1991; Wacquant, 1998). Nahapiet (2008) has further clarified the concept by emphasizing that social capital is a resource-based perspective. The connections, interactions and access to other resources that occur among social actors. Due to the diversification of application and emphasis, social capital is a very complex theory. Most of the discussion is based on the dimensions of the social capital.

Social capital is multi-dimensional concept. Structural, cognitive and relational are widely used dimensions in the literature (Hean, Cowley, Forbes, & Griffiths, 2004). Structural social capital is outside the observable interactions among the social actors. This can be networks within the community, such as the food market community. This also represents the rules and guidelines these structures have (Grootaert & Van Bastelaer, 2002). Cognitive social capital points to the shared goals/culture/language/narratives among the social actors (Monteverde, 1995). Shared goals means to have a common understanding or approach to network tasks (Inkpen & Tsang, 2005). In disaster management, having a common understanding among the

actors is crucial for dealing with the disaster. It enables a combined response and coping mechanisms that can enhance the survival rate of these organizations or other social actors (Dynes, 2002). Shared culture refers to the norms and rules of a particular community. As when people present in the network have similar cultural linkages, it becomes much easier to collaborate and share knowledge among the group.

The third dimension is relational social capital that focuses on personal relationships, trust and degrees of closeness between actors within the network (Nahapiet, 2008). Building and maintaining trust, through closeness and mutual respect, can reduce levels of uncertainty among social actors and thus foster collaboration in difficult times (Adler & Kwon, 2002). In terms of network, social capital can be seen from three perspectives, bonding, bridging and linking (Aldrich, 2011). Bonding ties are the ties among close family members, friends or neighbors in closed, tightly interconnected networks. There is localized trust and strict social norms (Adler & Kwon, 2002). Bridging social capital ties exist among extended group members, from other communities. It complements bonding capital, especially when communities are responding to the disasters (Sanyal & Routray, 2016). Linking social capital is enacted within a network, where the ties of the social actors reach to other actors outside the community, often powerful actors. This enables communities to access resources otherwise out of reach (Grootaert & Van Bastelaer, 2002).

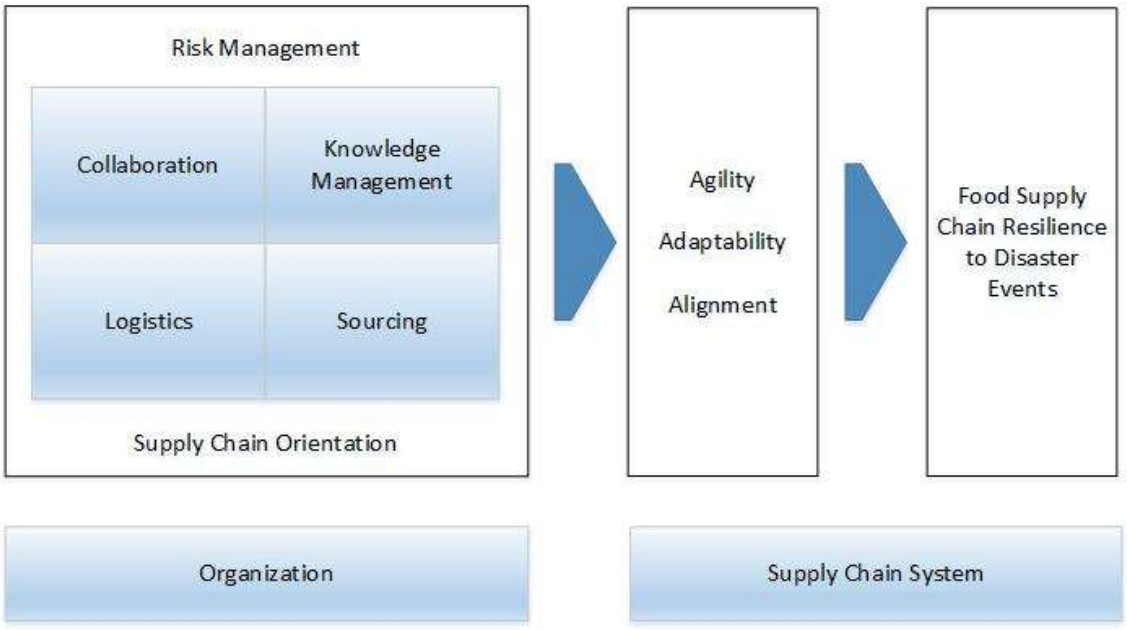
2.4 Conceptual Framework

Based on the literature review of disaster management and supply chain resilience theory, as well as other relevant theories, this thesis has developed a conceptual theoretical framework to advance this research (see Figure 2.4). Disaster management literature has emphasized four main areas of the supply chain that are considered important during disasters. These are knowledge management (Islam & Chik, 2011; Pathirage et al., 2012), sourcing (Ertem et al., 2010; Kovács & Spens, 2007), collaboration among different supply chain actors (Asgary et al., 2012; Jahangiri et al., 2011) and logistics (Holguín-Veras, Jaller, Van Wassenhove, Pérez, & Wachtendorf, 2012; V. Jain et al., 2012; Liberatore et al., 2014). This thesis argues that effectively dealing with these areas enhances the resilience of supply chains, as activities involved in these areas contribute towards achieving agility, adaptability and alignment. These are established capabilities/components of supply chain resilience in the pre-existing literature. These capabilities are gained through utilizing the network resources generated through relationships among network members (Barney et al., 2001). This view is also

supported by the relational based view of RBV theory. Further, network theory has been used to provide insights into the relationships and hierarchies among network members and how these network work. For example, in the area of collaboration, if organizations share information with each other, then this activity contributes towards achieving velocity and flexibility, that are part of supply chain agility, thus increasing resilience (Pettit et al., 2010). Similarly, it also helps with achieving alignment that ultimately leads to greater resilience. However, the literature is unclear on what these underlying activities actually are, and the levels of interdependent between these activities and how they relate to food supply chain resilience. Hence, this then is the primary objective of this thesis and justifies the need for this empirical investigation.

This review has identified the different facilitating factors that increase supply chain capabilities to encourage resilience. These include risk management and supply chain orientation. In the supply chain context, having strong and close relationships with suppliers and customers is the basis of surviving disasters. This strong relationship is only possible if individual organizations recognize the importance of these relationships. This recognition is called supply chain orientation and without this recognition logistics, collaboration, sourcing and knowledge management will be not effective.

Figure 2.4 Conceptual Framework



Source: Developed by the Author

Resilience is a bigger concept than risk management, as risk management is associated with smaller day-to-day disruptions (which have high frequency and low impact). If basic risk management is missing in the supply chain, then organizations cannot achieve resilience (which has high impact and low frequency and thus is far more critical). Therefore, this thesis contends that this is a facilitating factor for all of the four areas mentioned above.

2.5 Chapter Summary

This chapter has included literature review and developed a conceptual framework. This framewrok has included four main supply chain management areas (collaboration, knowledge managemnt, logistics, sourcing) that are crucial in disaster management. This framework suggests that each organization part of a supply chain perform certain activities within these areas that contribute towards the agility, alignment and adaptability. These three compnents are suggested as building blocks of supply chain resileince. A case study based methodology is used to conduct this research. This methodology is explained in the next chapter.

Chapter 3

Research Methodology

3.1 Introduction

This chapter presents the research methods used in this thesis. It begins with an overview of the overall research process. Based on the moderate constructivism paradigm (Järvensivu & Törnroos, 2010), this thesis uses qualitative research and a case study approach, both of which are explained in the following sections. To briefly summarize, data was collected from four different supply chains, in two different regions, using the conceptual framework developed in the previous chapter. This is followed by a discussion on semi-structured interviews, using accepted interview protocol. Information on the data analysis approach, validity and reliability of the research, limitations and ethical considerations are also included in this chapter.

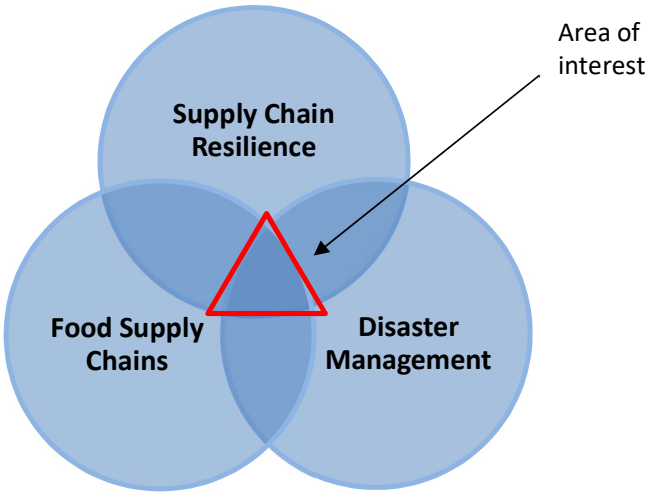
3.2 The Research Process

The research process used in this thesis consisted of multiple steps (Figure 3.2). The first step was the preliminary literature review which resulted in the identification of problems. As noted in the previous chapter, resilience is an emerging topic in the field of supply chain research. Disaster management is also a closely related discipline to resilience. Food supply chains are considered critical to provide relief to people during any sort of natural disaster. The continuous supply of food items is important for the overall community, as disruptions emerging from natural disasters can halt the overall system. Resilience of food supply chains in natural disaster context is the area of interest for this research (Figure 3.1). Key words used in search engines, databases and the university library catalogue were resilience, supply chain, food supply chain, disaster management, relief supply chain, supply chain risk management and food chain resilience.

After identifying relevant articles, papers and books related to supply chain resilience, disaster management, relief supply chains, it became easier to identify further journals, articles and books related to this research. The quality of journals was also kept in view while searching for literature. However, this was not the determining factor when highly relevant articles with good theoretical background were identified. The preliminary literature review was helpful in discovering emerging issues in the supply chain resilience discipline which helped in shaping

up the initial research questions and objectives. Research questions and objectives were refined several times in the process.

Figure 3.1 Main Research Themes and Locus of Interest

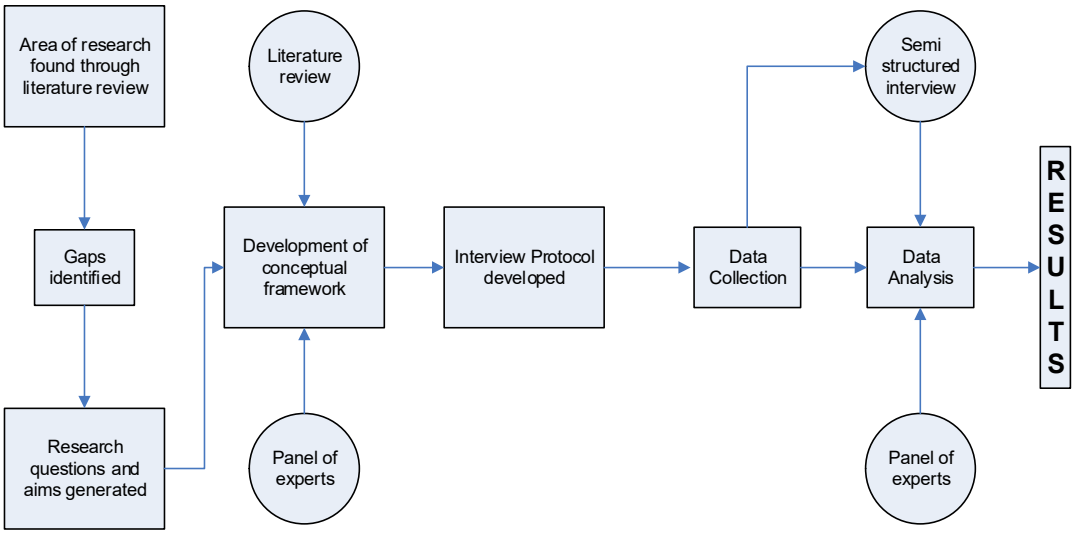


Source: Developed by the Author

The next step was to explore the literature to establish a suitable theory base for the investigation. Key concepts and areas were identified, and variety of frameworks and factors were explored in the literature review. Thereafter, a conceptual framework for food supply chain resilience was developed. Initially, the framework was a representation of several concepts and this was tested in front of a panel of experts from the Resilient Organization, Canterbury University, Christchurch, New Zealand. The Panel consisted of key personal from the disaster management and supply chain disciplines. The aim was to discuss, challenge and refine the conceptual framework, and to increase the reliability of the research. Initially the conceptual framework was just a bunch of different capabilities that led to supply chain resilience and factors of supply chain resilience which were discussed in the literature. These capabilities and factors were later categorized. Further refinement came, when two level were included in the framework: organization level and supply chain system level. Finally, capabilities grouping led to four major areas: collaboration, knowledge management, sourcing and logistics at an organizational level of the supply chain view. Agility, adaptability and alignment finally emerged as supply chain resilience factors at a system level. Two facilitating factors were included as part of the framework. From this, the research questions were refined.

The next step was to develop interview protocols. The literature was thoroughly referenced to generate relevant questions related to concepts included in the conceptual framework. Interview protocol is major way of increasing the reliability of the research and is used to guide the researcher in data collection (Yin, 2014).

Figure 3.2 Research Process



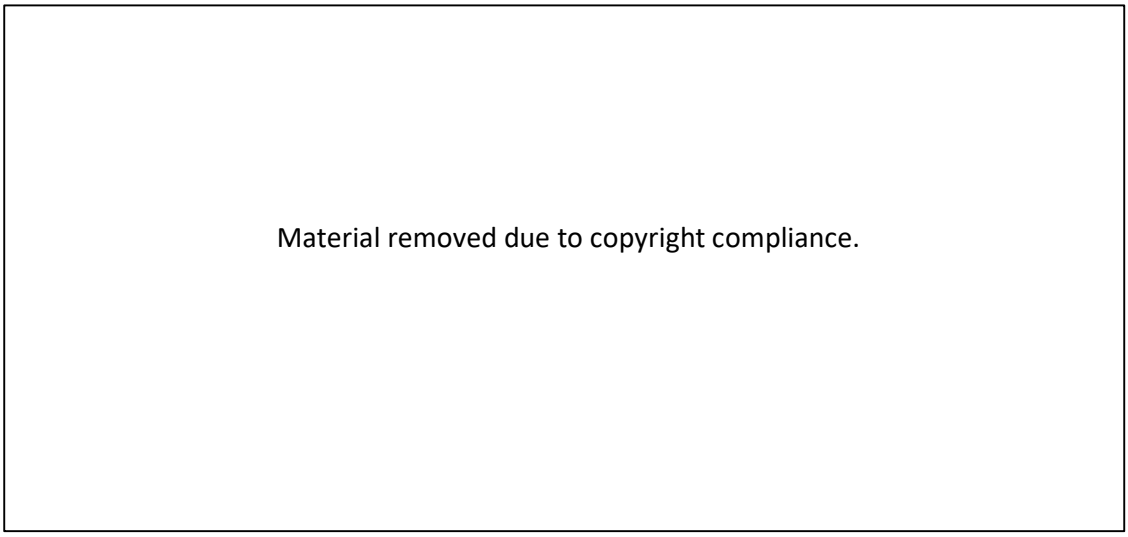
Source: Developed by the Author

The data was conducted in two regions, transcribed and then analyzed using cross-case comparisons. The data collection approach was qualitative (it used in-depth interviews as the main data collection method from key informants of four food supply chains in the South Asian region). A semi-structured interview technique was used. This research triangulated the results, through company reports and other relevant public documents as secondary data. During the research, respondents were also asked to clarify their responses if necessary. This exercise is called respondent validation and is used to validate research. Subsequently, feedback questions were also asked to capture respondents' perceptions which were used to validate the conceptual framework. All interviews were recorded electronically (DVR) and field notes and observations of the physical environment and non-verbal cues were taken. Handwritten field notes, along with the audio recordings, were converted to analyzable text. This text was then condensed, displayed and analyzed using NVivo (version 11). Finally, the

multi-case analysis was conducted, and the research questions discussed, and conclusions were drawn.

Saunders, Saunders, Lewis, and Thornhill (2011) state that research is like 'an onion' with multiple layers that must be peeled off before moving to the next one (Figure 3.3). Research philosophy, research design, approach, strategy, time-horizons and data collection are included respectively in their model. Based on the moderate constructivism philosophy (Appendix D), the following sections will explain all the layers peeled off in this thesis.

Figure 3.3 Research Onion



Source: (Saunders et al., 2011)

3.3 Research Approach

The deductive and inductive approaches are generally considered to be the two main research techniques used for empirical research. Depending upon the researcher's philosophical position, and the nature of the research questions, either one, or a combination of the two, can be used to answer the questions. A deductive approach logically follows a positivist paradigm, testing the theory through deductive reasoning, whereas an inductive approach is based on constructionism paradigm; that is, theory formulation from empirical data. The deductive approach is based upon quantitative data, while induction is normally based on qualitative data. Generally, induction has a more open and flexible approach which provides an opportunity to deal with any unexpected issues raised during the research (Johnsen, 2011).

The deductive approach is used primarily by natural sciences and is mostly applied when theory leads research (Saunders et al. (2011). A theoretical framework and hypotheses are developed, and the researcher tests that framework through quantitative data drawn from large samples. The researcher then generalizes this data to whole population (Bhattacherjee, 2012). Basic steps involved in the deductive approach are theory, hypothesis, data collection and analysis, leading to the acceptance or rejection of the hypotheses.

Where theory generation is the intended result of the research, this is called the inductive approach. Here generalized inferences are extracted from observations (Bhattacherjee, 2012). The inductive approach is somehow contrary, but complementary to, the deductive approach. The deductive approach is theory testing, while the inductive approach is theory building. For the inductive approach, the researcher collects data and, as a result of data analysis and iteration, new theory is generated. Due to the qualitative nature of the data, it is not highly structured like the deductive research. As the inductive approach is dependent on words and their analysis, reality is more subjective and depends on the perception of the social actors themselves, as well as the data.

It has been argued that supply chain network research, where inter-organizational relationships are the center of attention, is neither entirely inductive nor deductive (Dubois & Gadde, 2002). As a result, this thesis has mainly used the inductive approach with an element of the deductive. The deductive approach element is that this research is partially driven by extant theory, within strategic management and supply chain management domains. Indeed, this research will not test theory, rather, it will try to build on existing theory. Hence, this research has also developed a conceptual framework from existing literature on supply chain resilience, and it will be followed by an inductive approach, as this research is primarily concerned with qualitative data collection. Besides, the research context of a South Asian country in terms of food supply chains during disasters, has been little studied and creates a somewhat complex research setting. As Creswell (2013) has rightly suggested, if empirical research on the topic is limited, then the inductive method of generalizing from data would be the most appropriate method.

Many research strategies are suggested by different authors to use in qualitative research. Creswell (2013) has suggested five important research strategies of inquiry. These are narrative, phenomenology, ethnography, grounded theory and case studies. Narrative and

phenomenology are associated with the study of individuals. Anthropology is concerned with the broad cultural sharing behavior of groups, while grounded theory and case study is used when the researcher wants to explore events, activities and processes in-depth.

3.4 Case Study Methodology

The case study method was selected as the most suitable methodology according to the topic, research questions and the researcher's own philosophical position. Being a moderate constructivist, this researcher was interested in eliciting different, contrasting perspectives of supply chain networks, concerning food supply chain resilience. A case study is "an empirical enquiry which investigates a contemporary phenomenon in depth and within its real-world context especially when boundaries between phenomenon and context may not be clearly evident" (Yin, 2014). Thus, the case study approach is recommended when a researcher has to answer questions like 'how' and 'why'. Furthermore, if the researcher has no control over the behavioral events and research is focused more on contemporary events, case study methodology is recommended (Yin, 2014). Similarly, case study methodology is appropriate for exploratory investigations of some new phenomenon, which could be related to a person, group, family, situation, community or any cultural group (Meredith, 1998). Case studies deal with processes and put more emphasis on thorough analysis of a limited number of events and their interrelations. VanWynsberghe and Khan (2008) state that case study methodology does not have a specific disciplinary orientation, thus it can be used in social science, applied science, business and humanities. Easton (1995) highlights that the case study methodology is the most suitable approach to study business relationships and supply networks. Furthermore, Gummesson (2007) and Halinen and Törnroos (2005) have also pointed out the importance of case study methodology when studying supply networks.

Case studies can be used to accomplish different aims. Yin (2003) divides cases into exploratory, descriptive and explanatory. Eisenhardt (1989) recognizes description but emphasizes the roles of the case study in generating and testing theory. Stake (1994) highlights the intrinsic value of the case study, where rich description of a single case study is seen valuable. In management disciplines, theory generation seems the most discussed type of case research (Eisenhardt, 1989; Glaser & Strauss, 1967; Miles & Huberman, 1994; Yin, 2003). However, case studies can be used for other reasons as well, for example, to evaluate a case like a supply chain or a business network (Halinen & Törnroos, 2005), or to help

organizations to change. When the available literature is limited and no knowledge base is provided to develop good theoretical statements, then empirical study becomes more of an exploratory study (Yin, 2014).

Table 3.1 Types of Case Studies

	Exploratory	Descriptive	Explanatory
Purpose	This type of case study is used to study those areas or situations in which the phenomena being evaluated has no clear single set of outcomes (Yin, 2014).	This type of case study is used to present complete descriptions of the intervention within its real-life context (Creswell, 2013).	When a case study is used to answer the question that sought to explain the presumed causal links in complex real-life context that are too complex for survey strategy (Yin, 2014).
Questions	Why, How	Who, What, Where	How, Why
Example case studies	Peck (2005), Bozkurt and Duran (2012)	Coles, Zhuang, and Yates (2012), Kneafsey et al. (2013)	Agarwal and Subramani (2013)

This research is an exploratory study because it is contemporary in nature, with a limited knowledge base available, thus it depends on a case study to develop theory. An exploratory study is used to answer 'what is happening' questions. It is also used to seek new insights and to assess phenomenon in a new way (Robson, 2002). This thesis seeks to investigate broadly the area of food supply chain resilience, in the event of natural disasters and has developed theory in this new research area.

Along with approbation, the case study methodology has attracted criticism as well. This approach is considered to be too situation-specific and therefore one is unable to generalize results (Weick & Kiesler, 1979; Yin, 1994). Besides, it is also time consuming and extensive use of resources are also involved. Regarding generalization, if the researcher had chosen a single case study, with a limited sample size, the results would clearly be not significant in terms of statistical values (Alasuutari, 2010; Ellram, 1996). As such, the case study methodology is further criticized as the results of the case study are limited to only one specific situation and are not extendable to other situations (Gummesson, 2007; Yin, 2014). Indeed, the purpose of the case study is to gain a detailed picture of a given phenomenon, and as suggested by Stake

(1994) and Yin (2003), such expression ‘particularization’ or ‘analytical generalization’ should be used instead of only statistical generalization. Moreover, due to the large data sets generated during a case study, there is a possibility for the researcher to become overwhelmed and lose sight of the actual issues in question (Halinen & Törnroos, 2005).

Table 3.2 Strengths and Limitations of Case Study Methodology

Material removed due to copyright compliance.

Source: Vissak (2010), Creswell (2013), Yin (2014)

To deal with these critiques, the case study methodology should be effectively designed. ‘Cases’ should be selected based on certain criteria; all of the evidence of data collection should be documented, and the researcher should define a valid research processes (Modell, 2010). The unit of analysis should be carefully and systematically selected (Gummesson, 2007). Issues of validity and reliability must also be considered.

3.5 Case Study Design

It is essential to define the ‘case’ to understand case study design effectively. The term case in any case study is a construct, the subject of interest and/or an empirical unit. It is necessary to define the case as scientific and practical interests are associated with it (Scholz & Tietje,

2002). Eckstein (2000) defines a case as a phenomenon for which the researcher reports and interprets only a single measure on any pertinent variable. The case could be an account of an event/problem/activity. A case can also be an individual, organization, society or a group of organizations (Yin, 2014). Food supply chains are the focus of this thesis and as such, will be considered as the empirical unit of analysis. A thorough discussion on unit of analysis is provided in the following sections

A single case study is selected when the research area is unique and similar cases are not available (Scholz & Tietje, 2002). However, this strategy can be vulnerable if the case chosen turns out not to be the case which it was thought to be. Thus, Yin (2014) suggests using multiple cases which ensure the study's robustness (Table 3.3).

Table 3.3 Single versus Multiple Case Studies

Material removed due to copyright compliance.

Source: (Yin, 2014)

Yin (2014) has revealed an approach to multiple case studies in Figure 3.4 (below). The figure indicates that the first step is to generate some theory from the literature to guide the study, which in this study is presented in form of a framework. It also reveals that case selection and protocol development are also important steps in case study design and the data collection process. Each individual case should be considered as a 'whole' study. In each case convergent evidence is sought regarding facts and conclusions. Each case conclusion is considered to be information needing replication by other cases. Both individual cases and multiple case results should be the focus of the final report. The report should also include a discussion which explains certain results are part of one case study but contrasting elements in the other one(s).

Figure 3.4 Multiple Case Study Procedures

Source: Adapted from Yin (2014)

Many researchers have highlighted the benefits of using multiple case studies and the ability of this method to gather large amounts of data from multiple sources (Easton, 1995; Gummesson, 2007; Halinen & Törnroos, 2005; Kähkönen, 2011). The multiple case study approach is also appropriate for researchers who study business networks (Batt & Purchase, 2004). This thesis uses a multiple case study method to discover unique resilient approaches for each supply chain in real-life disasters (floods & earthquakes) context.

3.6 Case Selection and Unit of Analysis

Researchers must determine the number of cases that will be deemed sufficient. In qualitative studies, determining the total number of cases is discretionary, not formulaic. Judgment also occurs in non-case studies as well (for example, in the case of defining the "significant effect" in experimental science). Yin (2014) claims that if theory is straightforward, then two or three

cases may be enough, however, if the theory is more complex, then four to six replications can produce acceptable results. Four cases were selected for this thesis. Eisenhardt (1989) and Miles, Huberman, and Saldaña (2013) have suggested that the sample selected for qualitative research should be purposeful, or one which best serves the purpose of the study. As this research is focused on food supply chain/networks facing natural disruptive events, especially in the context of the developing South Asian country, the first step was to focus on areas most affected by disasters in our country of choice - Pakistan.

Figure 3.5 Flooding and Earthquake Zones in Pakistan

Source: (PDMA, 2008)

With the help of the National Disaster Management Authority of Pakistan (NDMA) (personal communication, May 2015), who deal with the whole spectrum of disaster management activities in Pakistan (www.ndma.gov.pk), and the South Asian Disaster Knowledge Network (WWW.SAARC-SADKN.ORG), which is a knowledge sharing platform among different stakeholders of SAARC (South Asian Association of Regional Cooperation) countries, the researcher was able to identify two areas in the country that are especially vulnerable to disasters. The first area or region (R1) is in the Punjab Province, which is predominantly agricultural land. This area is badly affected with severe floods almost every year (Tariq & van de Giesen, 2012). The second region (R2) is located in the KPK Province of Pakistan, which is vulnerable to earthquakes as well as floods (S. Khan, Chen, Ahmed, Ahmed, & Ali, 2012).

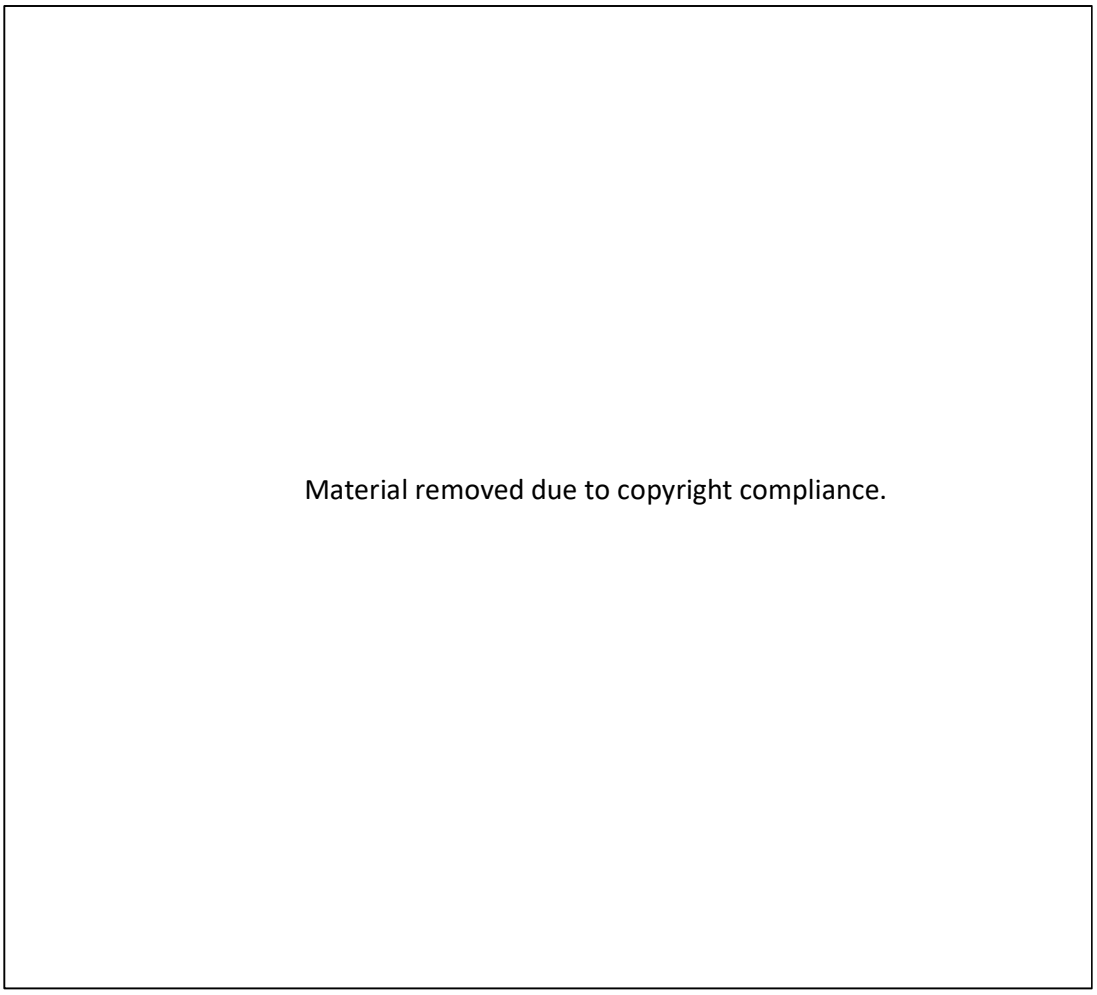
After finalizing the number of cases and geographical area of the study, another equally important task was to finalize the unit of analysis. Yin (2014) has suggested that single or multiple case studies can be examined from a holistic point of view with a single unit of analysis and may be investigated from an embedded view with multiple unit of analysis. As previously mentioned, this thesis used a multiple case studies method to investigate food supply chains/networks. Each supply network is comprised of different organizations (O1, O2 etc.) who work together to achieve the desired goals. The main issue of research was supply chains, and as defined earlier, four supply chains were selected for this study. Thus, this study has used multiple case study approach with embedded perspective having multiple units of analysis. At the very first level, the individual organization is the unit of analysis. The whole supply chain is the second level unit of analysis (see Figure 3.6).

Four food supply chains were ultimately selected for this study, two from each region, as these chains are particularly vulnerable to natural disasters and are crucial for survival and daily living. The literature highlights different relief food items, which are mostly provided by relief agencies to the community. These items include rice, flour, oil, dry fruits, juice, water and food grains (Clay Whybark, 2007; Day et al., 2012; Douglas, 2009; Kovács & Spens, 2007). Similarly, fruit and vegetables supply chains are exceedingly susceptible to flooding events in Pakistan. These are highly perishable commodities, and during natural disasters become even more vulnerable to deterioration. This thesis examined a staple food and fresh produce supply chain from each of the two regions. A large proportion of the population in these areas are also dependent on a continuous supply of fresh vegetables (Din, Parveen, Ali, & Salam, 2011; Ismail, 2010). The nomenclature for these four chains used throughout this thesis are C1R1, C2R1, C1R2 and C2R2. The first case (C1) in region 1 (R1) refers to the fresh produce chain in Punjab. Similarly, C2R1 denotes the staple food chain in Punjab, C1R2 is the fresh produce chain in KPK and C2R2 is the staple food chain in KPK.

3.7 Delimiting the Network

Related to unit of analysis, there were three other major challenges involved within the supply network study. As mentioned earlier, these are not mere four supply chains, but rather, each supply chain has multiple hierarchies involving hundreds of actors and suppliers, making it a complex network. Thus, problems related to network boundaries, complexity and case comparisons were inevitable (Halinen & Törnroos, 2005).

Figure 3.6 Case Selection



Source: Adapted from (Yin, 2014)

Case complexity was reduced by clearly defining the cases and limiting the context to two main natural disasters, floods and earthquakes; other disruptions and man-made disasters were excluded. Similarly, the research site was limited to the two main areas that are vulnerable to these disasters. Complexity was also minimized with the help of a single interview protocol for all of the respondents and by sticking to the research objectives. The third step was related to the selection of one staple food and one fresh produce supply chains from each region, hence allowing clear cross-case comparisons. In addition, the same theoretical base and framework was used which also facilitated the process of cross-case comparison.

However, a major problem was related to delimitating the networks. Defining a network's boundary depends on the research problem and the researcher's judgement. This research is focused on end-to-end supply chain resilience, beginning with the farmers and ending with the final consumers. It includes the relationships among the suppliers as well as with the buyers. Subsequently, the second level unit of analysis is the whole supply chain. The micronet-macronet typology is the best fit for this research, with some modifications. Halinen and Törnroos (1998) have proposed four ways of de-limiting business networks (Figure 3.7). These four networks can be described as actor-network, dyad-network, micro-macro network and intranet network. As this study concerns food supply networks and was interested in taking views of the full supply chain, the micro-macro network was chosen. At the macro level, these food networks comprise of thousands of actors (business units as well as Government institutes, NGOs and humanitarian organizations). Within this macro network, the researcher approached individual actors to question them about important buyers and suppliers. Next, it traced those actors till the end of the supply chain at both upstream and downstream levels (Figure 3.7, E). In this way, the researcher was able to chart each buyer and supplier as well as provide a horizontal view of actors at the same level. There were a number of challenges in reaching these actors as these networks are embedded in larger social and political networks. These are discussed in the following sections.

Figure 3.7 Delimiting the Business Networks

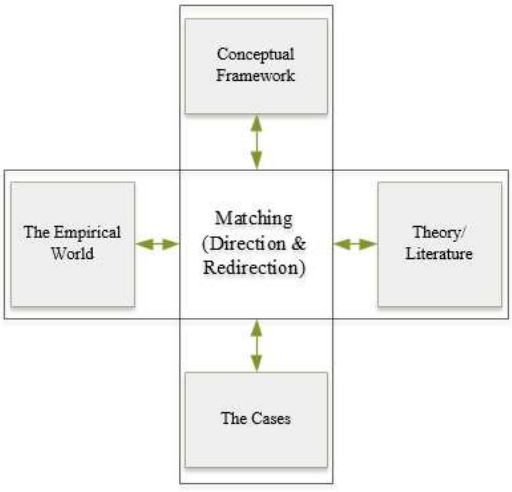
Source: Adapted from (Halinen & Törnroos, 2005)

3.8 Systematic Combining

Qualitative research is often criticized for its lack of valid processes. To remedy this, the researcher has used systematic combining (Figure 3.8) as suggested by Dubois and Gadde (2002). This process allows iteration and is used primarily in case study research. The conceptual framework, theory, fieldwork and case analysis are all developed iteratively in this approach. As the main objective of any research is to confront theory with the real world, systematic combining makes it sure that this confrontation is continuous back and forth throughout the research.

One of the main features of theory generation from the case study approach is the numerous overlaps of data collection and analysis (Strauss & Corbin, 1990). This is called the 'matching process,' in the systematic combining approach. Dubois and Gadde (2002) define matching as going back and forth between each case, framework, data collection and analysis. The way of achieving is through direction and redirection of the study. This direction and redirection holds true for theory, case and data source. Including multiple data sources is one technique which can be used to achieve this. According to Yin (2014) and Miles et al. (2013), multiple sources are required to triangulate data, which in return increases the validity of the research. However, in systematic combining, triangulation not only increases validity, but it also leads to the possibility of discovering new phenomenon in a given context.

Figure 3.8 Systematic Combining



Source: Adapted from (Dubois & Gadde, 2002)

The conceptual framework is also important in this approach. The conceptual framework is usually a graphical representation of the main concepts and their interrelationship. Drawn from the literature, the framework was developed at the start of the study and evolved gradually as the study progressed. It is a general guideline for the main concepts that are to be studied in the real world (Miles et al., 2013). Once the researcher has started data collection, and with more of a grip on the relevant literature, the framework is revised and becomes more precise over time.

In this research, systematic combining occurred many times while going back and forth between different aspects of the framework. Initially, the researcher was focused on disaster management which led towards the humanitarian supply chains. A partial framework was also developed at that time to effectively manage the supply chains in disruptive events. A full literature review paper was presented at a prestigious conference in New Zealand which led the researcher to explore more emergent issues in this discipline. Commercial supply chains and disaster management were the missing links. The researcher reflected back on the literature, new themes emerged which were included in the conceptual framework more tilted toward the commercial chains, but with added elements taken from the disaster management discipline. Initially, the conceptual framework was a mixture of many fragmented concepts that was thought to lead to resilience in food supply chains. However, with regular meetings with the research committee and going back and forth in the theory, a number of concepts were merged, and others were discarded. The new framework, along with the theory, was again presented at another international conference in Queenstown, New Zealand, as well as discussed with a research group called Resilience Organization, based at the University of Canterbury, New Zealand. The South Asian region was chosen as an area that could generate rich data. As noted earlier, this region is more vulnerable to natural disasters and food chains are the backbone of the region's economy. The following section explains the data collection process, research protocol, case selection and data analysis as they were developed side by side.

3.9 Data Collection

The prime source of data collection was through interviews that were supported by observations, informal conversations and a review of archival secondary sources.

3.9.1 Research Protocol

Research protocols are used to enhance the validity and reliability of qualitative research (Yin, 2014). A research protocol contains the rules, procedures and introduction of the concerned research. Interview questions are the main elements of this instrument; it contains the main questions to be asked and specific data that is required. Questioning prompts are also included in this instrument, ensuring that all the topics are covered during any interview. It also maintains uniformity across all of the interviews, thus increasing the reliability of the research (Voss, Tsikriktsis, & Frohlich, 2002). In this study, the researcher used the 'funnel format' to develop the interview protocol (attached in Appendix B). This protocol starts with broader introductory questions about supply chain partners, buyers, logistics and business history. It then moves on to core questions related to the preparation, response and recovery from any recent disasters. Conventionally, the research aims are introduced, as well as the purpose of the study, at the start of the protocol, while questions related to different aspects of the conceptual framework come later. The prompts, as well as the main research questions, were refined several times as the literature review progressed. After the development of an initial draft, the researcher tested the instrument on several knowledgeable persons, such as the head of the Supply Chain Management Department at Lincoln University, New Zealand, members of the research committee of the Resilient Organization, Canterbury University, New Zealand. The initial view was that it was very lengthy, as it took almost two hours in one of the test interviews to complete. The instrument was revised based on these comments; some questions were merged, or removed, while efforts were made to clarify ambiguous questions and simplify the wording.

3.9.2 Protocol Translation

As the research setting was based in Pakistan, where the main language is Urdu, not English, the research instrument was translated to the native language. This involved a systematic approach and involved two further researchers who also belong to the same region. The instrument was sent to these two researchers who translated the English copy, word-for-word into the native language. Simultaneously, but separately, the researcher also converted the instrument into the native language. Google translate, and other online dictionaries were used to convert difficult words which have compatibility issues in both languages. The three translated versions were then reviewed in a combined meeting to ensure that each question,

as a whole, carried the same, or near, meaning, thus leading to some changes in sentence structure. The final drafted instrument was tested on one other Urdu speaking person who further refined it. The last stage was to back-translate this instrument from Urdu to the English language to make the process valid. A few further minor amendments were made, but it was clear that the meaning of the questions was compatible.

3.9.3 Semi-Structured Interviews

There are three main types of interviews which can be conducted in qualitative research. These are structured, semi-structured, and unstructured (Saunders et al., 2011). Structured interviews use specific questions, seeking definite answers and a questionnaire protocol is commonly used (Whiting, 2008). For this research, semi-structured interviews were selected as the most appropriate, to ensure not only that protocol was followed, but also to allow for a more flexible approach suitable for the research objectives. In semi-structured interviews, the researcher has more flexibility in asking questions and probing for more in-depth knowledge about a given topic according to the flow of the conversation. For this research, most of the interviews conducted were individual one-to-one interviews, however on several occasions group interviews were also conducted. These group interviews gave greater insights about the phenomenon, drawing on the varied experiences of people involved. For example, in C1R1, a group interview of two middlemen was conducted; they were competitors which made this interview even more interesting and some rich information was collected through this process. Twenty-two follow up interviews were also conducted, mostly with commission agents sitting in the markets, to clarify important points, as well gather more data. Most of the follow up interviews were conducted via telephone because of time and travel constraints.

In the data collection phase, the researcher's role was that of an investigator, who was looking for the facts about the preparation, response and recovery phases of the disaster. Leonard-Barton (1990), Yin (2003) and Creswell (2013) all mentioned the many qualities which a researcher should possess in order to conduct a good interview. These include; good listening skills, and an unbiased, flexible and adaptable nature.

While conducting these interviews, the researcher has took special note of detail, and always sought vivid and nuanced answers which enable the generation of key themes (Rubin & Rubin, 2011). Trust and rephrasing questions in simpler way was the key to achieving these characteristics. The lack of trust in this society was a major problem during the data gathering

phase. Potential people and organizations were afraid of giving interviews in anticipation of some political or legal threat. As such, good interview skills, as mentioned above, and social references from creditable sources, were used to acquire the trust. This included proof of enrolment in the hosting University and evidence of the legitimacy of the study.

Depth and detail can be viewed as similar concepts, but these differ in meaning. Detail means going after different parts of the phenomenon, while depth means going deeper into one part. By asking for detail, the researcher encouraged respondent to cover different aspects of the story. For example, when one of the respondents spoke about the recent flood which caused much damage, the researcher asked for more detail (what was your reaction, where did you go for help?) Depth, on the other hand, is all about seeking distinct points of a single aspect. For example, one of the respondents praised his supplier's support in dealing with the aftermath of the flood. At this point the researcher asked him to tell him more about it (who is that supplier? How long have you had a relationship with him? What sort of help did he provide) to gain greater depth.

In addition to depth and detail, vividness and nuance was also addressed in the interviews. Vividness comes through the step-by-step description of the event. The researcher asked about the background of the respondents, their suppliers, buyers, logistic providers and any other actors involved to ensure that the information obtained was vivid. For example, in one of the vegetable markets, the Commission Agent talked about extreme flooding which completely submerged the market. They then explained how all of the market members (even competitors) worked together to clean up, providing some evidence of the underlying concepts of collaboration and coopetition. Similarly, nuance implies that there can be several views of a single phenomenon. Nuance requires a description of something, not just a black and white answer, but precise descriptions. For example, the researcher asked almost all of the respondents whether they trusted their suppliers. If someone answered yes, then the researcher asked the respondent to explain how they understood trust, which differed for all of the interviewees. Finally, richness comes through extended conversations. The researcher encouraged respondents to speak more about each situation by asking probing questions, showing intent to listen more and hence showed commitment. Importantly, the fact that the researcher was part of the local culture meant he was more readily accepted and trusted. Often this meant ordering a cup of tea or lunch for the respondents to demonstrate his intention of spending time and listening to more stories.

Secondary data was also collected. Observation is more humanistic methodology to collect data and it involves the systematic recording and noting down occurrences, behaviors and processes in the social setting of the research (Marshall & Rossman, 2014). In this research, personal observations were recorded during meetings with different supply chain members and also by visiting the markets where actual transactions were happening pre-and post-interviews. Photographs, notes and a digital voice recorder were used to collect the interview conversations and other observations.

Secondary data is invaluable because it supplies additional evidence of the wider context of the study and thus helps triangulate the phenomena (Yin, 2014). In this research, data related to overall region's economic, social, technological and governmental situation was collected using, official (government) reports, work process documents, handouts, receipts, transactional documents used by different actors, manuals, rate list of items, farming brochures and reports, market manuals, PDMA research reports and other humanitarian company reports about regional food supply chains. These all provided rich insights and confirmation of the context and findings of this study.

3.10 Sampling

This research used non-probability sampling to select the population for study. In this type of sampling technique, units are purposefully selected to reflect specific features of the population (Sekaran, 2006). The intention of this approach was not to be statistically representative, therefore desired characteristics of the population was the main selection criteria. This is why a number of authors have recommended non-probability sampling for small scale explorative studies (Bhattacherjee, 2012; Lewis-Beck et al., 2003; Miles et al., 2013; Sekaran, 2006; Yin, 2014). Within the non-probability sampling techniques, a purposive sampling method is used with the elements of convenience and snowballing sampling methods.

Purposive sampling is the technique used to identify and select individuals, groups, and organizations that are knowledgeable about the topic of interest or have experience in the field (Palinkas et al., 2015). Sample sizes were not fixed prior to the study; it depends on the resources, time available and theoretical saturation of the required study (Rubin & Rubin, 2011). Therefore, it is more suitable for studies where analysis and data collection go side by side, such as in this research. Using purposive sampling, key organizations and commission

agents in the fruit and vegetable and grain markets of R1 and R2 were contacted. Internet and social media platforms were also used for this purpose, other than referrals from the Disaster Management Cell in the government. While selecting informants, three points were used as guidelines: knowledgeable about the situation (has faced some disaster or its effects in the recent past), willingness to talk and diversity of views (big and small markets, different business situations, different areas). Each respondent interviewed meet these basic criteria.

As part of the purposive sampling method, sequential sampling (that is, the snowball sampling) was also used. This was an effective way of finding supply chain actors, beyond the initial contacts, as food supply chains in these regions are fairly interconnected. Each informant was asked about their main suppliers and buyers (first tier), also limiting the network. In this way, all of the key actors interviewed, thus rolling the 'snowball' to each end of the supply chain. Due to time and travel constraints, the researcher selected the study units that were easily accessible. This form of sampling is sometimes called convenient sampling (Saunders et al., 2011). Qualitative study samples are usually small in size as there is no hard and fast rule to ensure sufficient scale to statistically prove the estimates. The qualitative researcher looks for rich and nuanced data.

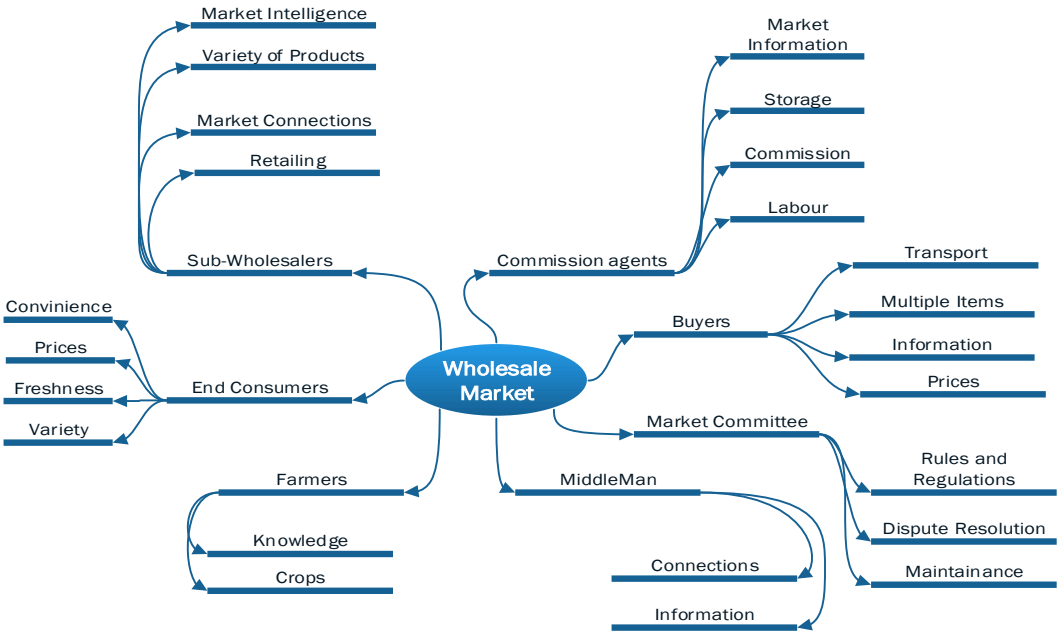
In the preliminary stages of this thesis (December 2013-March 2014), the researcher conducted two interviews with emergency relief providers in Pakistan; the National Disaster Management Authority (NDMA) and the Punjab Disaster Management Authority (PDMA). The researcher wrote a formal letter to the managing directors of these organizations, seeking appointments for interviews. Both agreed to be interviewed (the Procurement manager of the NDMA and Managing Director of the PDMA). These interviews were unstructured to gain an overall image of disaster management in Pakistan and how these companies provide relief to affected populations. Through these interviews, an overall picture of vulnerable areas and people was revealed. These organizations also shared archived data and reports which further clarified the overall conditions in these areas, in relation to natural disasters. Further literature was reviewed that resulted in developing research questions and a conceptual framework that focused on the activities of commercial food supply chains that face frequent major natural disruptions.

Data collection related to the four chosen supply chains began in October 2015 and ended in February 2016. Through the initial interviews of the above-mentioned organizations and the

researcher's own local knowledge, it was evident that the entry points for these supply chains would be the large wholesale markets where commission agents conduct their business. To illustrate how these whole-sale markets operate, Figure 3.9 is presented below. However, a detailed analysis of these markets is provided in the analysis chapters. Agriculture is the main sector of Pakistan's economy; approximately 70% of the population is directly or indirectly engaged in farming, distribution, processing and production of major commodities (Division, 2011). Rice is one of the major crops of Pakistan, with an annual rice production of 6.7 million tons (Raza, 2014). Similarly, Pakistan produces almost 9 million tons of fresh vegetable and fruits annually (Ishaq, Rathore, Majeed, Awan, & Zulfiqar-Ali-Shah, 2009). As these are the main agricultural commodity groups, our sampling will include staple products such as rice and fresh products.

Except for a small quantity of these products, that are kept for personal use or selling directly to consumers at the farm level, all remaining quantities must pass through the wholesale market system in order to reach to end consumers. These wholesale markets are traditionally set up by the government and are a pivotal point where sellers and buyers meet to execute transactions. Commission agents are basically the main custodian of these markets as they are allocated shops here. Therefore, the researcher established contacts with these commission agents in order to enter these supply chains. Agriculture market information system (www.amis.pk) provides a database of commission agents operating in different markets in the Punjab region; the researcher contacted some of the commission agents via phone, to gather information related to the research. During these conversations, the researcher made sure that these commission agents fulfilled the three points criteria of purposive sampling procedures mentioned earlier. Most of the agents were reluctant to be part of this research; this is common cultural dilemma that people tend to avoid strangers. However, two of the commission agents agreed to give face-to-face interviews. The one major success at this point was that commission agents' business was not attached exclusively to one single item. Rather, every commission agent was doing business in multiple products. For example, an agent who sold vegetables was also involved in fruits, as well as, wheat, lentils and rice. Therefore, instead of calling these as vegetable and rice supply chains, researcher named them fresh produce and staple food supply chains. Nevertheless, the researcher ensured that major businesses of these supply chains constituted rice and vegetables.

Figure 3.9 Wholesale Market Components



Source: Developed by the Author

The researcher also used his extended network of friends and acquaintances to find further contacts; this resulted in three more interviews. Social media, mainly Facebook and Twitter, were also very helpful. Here the researcher updated his status about his research and asked for possible contributions or help in finding suitable respondents. Seven of the social activist and persons related to disaster management were also contacted through Twitter. One of those people in R2 contacted and assured his help, similarly two contacts were found in R1.

Early in the data gathering phase, letters were addressed to the PDMA and other government departments (City District Government Local Body) asking for appointments, interview referrals and help from their staff to be part of the interviews. This step was taken as early information demonstrated that these institutions are part of each market committee and that respondents would be more willing to talk if someone from the government attended. In total, 52 of people were approached for an interview (37 agreed, giving a response rate of 71%). In total, 37 interviews were conducted in this study across the four supply chains in two regions (See Table 3.4).

Table 3.4 Key Informants Related Information

Case (C) & Region (R)	Position in the supply chain	NVivo code	Key Informant	Total Experience (Years)
C1R1	Focal Wholesale Market Commission Agent (CA)	CA1-C1R1	Business Owner	>15
	Focal Wholesale Market Commission Agent (CA)	CA2-C1R1	Business Owner	Not available (NA)
	Supplier: Farmer (Fr)	Fr1-C1R1	Farm Owner	>15
	Supplier: Farmer (Fr)	Fr2-C1R1	Farm Owner	>10
	Supplier: Middleman (MM)	MM1-C1R1	Business Owner	NA
	Supplier: Middleman (MM)	MM2-C1R1	Business Owner	12
	Distributor: Wholesaler (WS)	WS1-C1R1	Manager	>20
	Distributor: Wholesaler (WS)	WS2-C1R1	Manager	>10
	Retailer (Rt)	Rt1-C1R1	Supply chain manager	>5
	Retailer (Rt)	Rt2-C1R1	Business Owner	>10
	Market Committee Government Representative (GR)	GR1-C1R1	Town planner	NA
C2R1	Focal Wholesale Market Commission Agent (CA)	CA1-C2R1	Business Owner	>20
	Focal Wholesale Market Commission Agent (CA)	CA2-C2R1	Business Owner	NA
	Supplier: Farmer (Fr)	Fr1-C2R1	Landlord	>10
	Supplier: Farmer (Fr)	Fr2-C2R1	Farm Manager	>5
	Supplier: Farmer (Fr)	Fr3-C2R1	Landlord	>10
	Supplier: Trader (Tr)	Tr1-C2R1	Business Owner	NA
	Supplier: Trader (Tr)	Tr2-C2R1	Business Owner	>5
	Distributor: Brokers (Br)	Br1-C2R1	Manager	>10
	Retailer (Rt)	Rt1-C2R1	Planning officer	NA
	Labour Supplier (Ls)	Ls1-C2R1	Business Owner	NA
C1R2	Focal Wholesale Market Commission Agent (CA)	CA1-C1R2	Business Owner	NA
	Focal Wholesale Market Commission Agent (CA)	CA2-C1R2	Business Owner	NA
	Supplier: Farmer (Fr)	Fr1-C1R2	Farm Owner	>20
	Supplier: Farmer (Fr)	Fr2-C1R2	Farm Manager	>10
	Supplier: Middleman (MM)	MM1-C1R2	Business Owner	NA
	Distributor Wholesaler (WS & CA)	CA3-C1R2	Manager	NA
	Distributor Wholesaler (WS & CA)	CA4-C1R2	Manager	>15
	Retailer (Rt)	Rt1-C1R2	Business Owner	NA
	Retailer (Rt)	Rt2-C1R2	Business Owner	NA
	Market Committee Member (MC)	MC1-C1R2	Coordinator	NA
C2R2	Distributor Wholesaler (WS)	WS1-C2R2	Manager	>10
	Distributor Wholesaler (WS)	WS2-C2R2	Manager	>20
	Distributor Wholesaler (WS)	WS3-C2R2	Manager	NA
	Distributor Wholesaler (WS)	WS4-C2R2	Manager	NA
	Retailer (Rt)	Rt1-C2R2	Manager	>15
	Retailer (Rt)	Rt2-C2R2	Manager	>10

3.10.1 Food Chains in Region 1 (Punjab)

The research began the data collection by visiting one of the fruit and vegetable markets in Lahore city. Here the researcher recorded observations about the processes; the loading and unloading of items, storage facilities, and how staff dealt with customers. Three people were contacted who showed interest in giving an interview. According to these observations, the interview protocol was further simplified in terms of language, as the average level of education was very low. The replies from some of the letters written to government officials were also fruitful, and one of the District Municipal Officers (in-charge of one of the largest fruit and vegetable markets in the region) agreed to assist with data collection. Being a key stakeholder, he was also interviewed. With his help, Commission Agents were contacted, and interview times and locations were arranged. All of the interviews were conducted in business premises, or close by, as this was the largest market in the region. Initially, two interviews were conducted with two separate commission agents and they introduced the researcher to their immediate suppliers and buyers. In short, farmers, middlemen and all other supply chain actors were also introduced through this snowball technique.

All of the interviews were transcribed within a day or two and on the next visit were discussed with the respondents. These new interviews were also recorded. Being accompanied by the government officials made it easy to approach, and be welcomed by these respondents, but it made it equally difficult to collect some important information as they were reluctant to provide sensitive information (financial information). By utilizing the best interview practices and trust building techniques, the researcher was eventually able to elicit this information. Some of the respondents asked for an official letter from the hosting University to assess the credentials of this research as being for academic purposes only. Anticipating this issue, the researcher had such a letter written and issued by the University prior to data gathering, thus helping to gain the trust of these respondents.

Besides the fresh produce (C1R1), respondents from the staple food supply network (C2R1) were also approached at the same time. Three of the commission agents who were shortlisted from the agriculture marketing information system were contacted again and appointments made over the phone. They were interviewed and shared information about their buyers and suppliers. One of the respondents interviewed, was one whose contact was made via social media. This person invited the researcher to his home and later helped in telephonic interview

of one of his main suppliers. The researcher traveled with this person to rural areas, where he was able to interview farmers. This person also gave the contact details of one of his major buyers, a rice mill, whose general manager was interviewed later on.

Most of these initial interviews urged the researcher to visit Kamoki grain market, which is one of the largest in Pakistan. The researcher interviewed a rice trader who happened to be in the extended circle of his family. This person was purchasing rice from the same market and had a few contacts in Kamoki market. In the last week of December 2015, the researcher traveled by road to this market where commission agents were interviewed and then one of the middlemen accompanied the researcher to off-sites to different local regions where rice mills, farmers and whole sellers were interviewed.

All of the interviews were recorded with the permission of the respondents and where respondents denied recording (five of them), hand written notes were taken. While the main source of data was the interviews, other observations were made by repeatedly visiting the markets and other small markets in the region. These observations focused on their preparations for disasters, physical conditions, the nature of the interactions between the interviewee and their suppliers and buyers, and the state of the physical infrastructure, such as storage facilities and transportation. Secondary data sources, such as information sharing sheets, rate lists, tax documents, safety rules, newspaper articles and other reports written on these chains were also collected. All of the data was transcribed side-by-side with these interviews, and a translation service (Transcribe Wreally) web application was used for these transcriptions.

3.10.2 Food Chains in Region 2 (KPK)

Gathering data in R2 was more challenging. This was mainly due to the remote geographical location and the enduring war on terrorism centered on this province. Before travelling to the capital of this region by local transport, an authority was obtained from the military to approve movement in the region, and also because the local population's friendlier relations towards military personal. A person who is associated with the humanitarian organization was contacted via Twitter, and with his references, the researcher was able to visit local fruit and vegetable markets. Initial interviews were recorded in the largest market of the region, and then through snowballing, new contacts of farmers and buyers were established and then interviewed.

Two contacts were also referred by the commission agents from R1 and were subsequently interviewed. In this region the people are generally friendlier and practice a strong tradition of hospitality. However, due to the war on terror, they were quite afraid of talking to strangers. The vegetable and fruit markets more or less operate in similar fashion as R1, yet the staple food chains are quite different. As all the rice are cultivated in the Punjab region (R1), and those markets supply this province, there are large wholesale markets in different cities. One of these large wholesale markets was visited by the researcher who recorded interviews with the wholesalers. In the first week of January 2016, the researcher travelled further north on a military vehicle and interviewed respondents in the local markets of Mardan, Batkhela, Mangora, and TakhtBhai. One farmer who was selling his product directly by the roadside was also interviewed. During this period, the interviews were transcribed, and transcripts were validated by the respondents.

In addition, observations were made regarding the damage from earthquakes and floods, transactions between different actors, market structures and conditions, body language, dealing with customers, as well as transportation and storage conditions. Secondary data was also collected in the shape of reports, rate lists, market committee rules and regulations.

3.11 Data Analysis

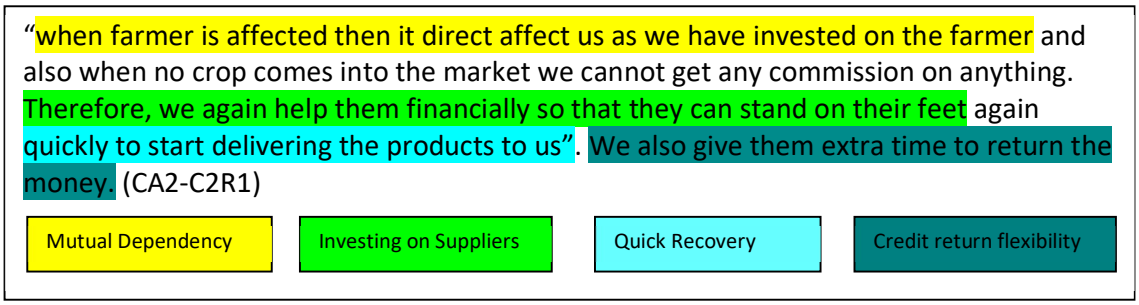
In qualitative studies, data analysis starts alongside the data collection. This technique cycles back and forth between thinking about the existing data and identifying new areas for data collection. This analysis is dependent on three contemporaneous steps; data condensation, data display and conclusion drawing (Miles et al., 2013). Data condensation is the process of focusing and simplifying large amounts of data gathered from interviews, field notes, documents and any other relevant source. Generating codes, concepts and themes is also a key part of this process. In this thesis, data condensation began with the development of a conceptual framework, research questions and reliable data collection methods, thus condensing the overall body of literature by selecting and focusing on relevant areas and research gaps. This process also compliments the systemic combining philosophy that framework, case study, collection methods and analysis evolve side-by-side.

Concurrently, writing detailed case study reports and making matrixes to display the data is part of the data display step. This helps confirm the data coding and also emerging themes from the analysis that leads to final conclusions. Data coding and theme generation are the

most important steps in qualitative data analysis. Based on the above three steps process, the data collection phase and the systematic analysis all started with the interviews and ran concurrently alongside the data collection. The motive was to modify the research direction and hence protocol based on new findings for further interviews. The transcribed files were crossed checked with the field notes, which were developed during the interview process, to enhance the quality of the transcribed files. The written transcribed files were shared with the respondents and feedback was sought (Kvale & Brinkmann, 2009). This improved the validity of the research. These interactions with the respondents helped in generating and refining the themes and also strengthening the findings of this research. After verification by participants, all of the data was coded and concepts were developed iteratively. Based on these codes and concepts, themes were later generated that were triangulated with the observational and secondary data. Queries were then run in NVivo 11 software to display the data. This data was compared with the literature and theory to generate the conclusions.

The coding of the data is a complex process. Even from small paragraphs, more than one code and concept could emerge (Figure 3.10). The development of codes, categories and themes in the NVivo 11 software was accomplished using Silver and Lewin's (2014) four step approach. It also drew on a number of other general approaches to coding data by other authors (Hesse-Biber & Leavy, 2010; Miles et al., 2013; Saldaña, 2015; Yin, 2014).

Figure 3.10 Multiple Codes



Source: Developed by the Author

In the data interrogation process, the first step is to organize the data. In this phase, the researcher became very familiar with the source data, interview transcripts were read, re-read, field notes were reviewed. Similarly, secondary data was organized, and literature was referred to for more insights. Furthermore, the data was sorted, and an interpretation frame was also built.

Firstly, all of the interview transcripts were imported into NVivo in the source section. These were then copied into the internal section into four separate folders, to accommodate the four separate supply chains. Relevant secondary data was also entered here, and all the observations were saved in the memos section. Pictures related to each site were also attached to the appropriate internal folders.

The next task was to develop the interpretation framework. This can be done according to the research questions as well as the conceptual framework. In NVivo this step is also known as generating the initial 'nodes'. Nodes are basically the container in which data is kept generating themes and run queries to display the data. These initial nodes were generated according to the detail of the original conceptual research framework. The three main nodes initially generated were the concepts of; vulnerabilities, capabilities (Collaboration, Knowledge Management, Logistics and Sourcing) and facilitating factors. Within these initial containers, further containers were generated according to pre-coding themes. These pre-coding codes were drawn from the literature and interview protocol. Further codes were then generated by reading the transcripts, and initial codes were then merged or expanded as the data coding progressed.

Simultaneously, the classifications section in the NVivo was used to classify the sources of data, according to the different supply chain actors being interviewed. Initial coding was also done in this step. The automatic coding function of NVivo was not used here, as the researcher wanted to code the whole database manually in order to help with familiarization. This process greatly assisted in creating a clearer picture of how the data was 'talking' and the key themes that started emerging even from this first early round of coding.

The second step is data exploration. Here, codes developed in first phase are transformed into concepts based on resemblances and distinctions. Also, less important codes where subsumed into higher level codes. Codes and concepts are marked and annotated using the annotated tools available in NVivo. The third step is integration, where codes and categories are connected together, hence generating patterns. Here, all of the first order codes were examined in relation to the hypothesized three supply chain resilience components of; agility, adaptability and alignment (see Appendix A). Appendix A shows the relation between resilience components and underlying activities of four supply chain areas chosen for this research. In the fourth step – interpretation – queries are run to examine the comparison and

other data display tools (tables, graphs, matrices, flowcharts) are used to make connections among different categories. The final analysis is written along two approaches: descriptive and interpretative. The descriptive level narrates individually the whole supply chain and all of the relevant stories told by the respondents. The supply chain operations reference (SCOR) model is used here to describe each supply chain. This model is developed by Supply Chain Council and provides the basis for categorizing business activities to enhance the overall supply chain performance (Supply Chain Council, 2008). SCOR model has four levels, however this research has only utilized the first level process categories (plan, source, make, deliver) to describe the four supply chains. This helped to bring a symmetry and a common vocabulary as well as a simple understanding of these complex supply networks. The interpretative approach reveals the deeper themes and connections of these themes to the main research questions and conceptual framework for resilience in food supply chains.

3.12 Reliability, Validity and Generalizability

Reliability and generalizability are key assessment criteria for assessing the quality of any research. Nonetheless, these two assessment criteria are related to the positivist approach (Yin, 2003). As this research is interpretive in nature, these are not applicable here. This thesis' aim was to study a contemporary phenomenon and other than generalizing the findings, interpretation and explanation of the events are main concern for any qualitative research (Alasuutari, 2010). Qualitative studies cannot be replicated as the real world is changing constantly. Each interpretation is unique and replication is not relevant in these studies (Marshall & Rossman, 2014; Strauss & Corbin, 1990; Yin, 2014). Instead, authenticity and internal validity are focal issues in qualitative research.

When discussing these quality issues in qualitative research , Lincoln and Guba (2000) assert that qualitative interpretations can be improved by four factors: credibility, dependability, transferability and conformability. For this research, the following table explains the steps taken to improve the quality of this research.

Table 3.5 Assessment Measures Taken

Criteria	**Steps Taken**
Credibility (Internal Validity)	a) Prolonged engagement in the field: researcher was familiar with the local culture and contacts were also

Criteria	Steps Taken
Credibility establishes the extent to which the research finding is a true interpretation of the participant's original views	established with respondents long before the data collection stage b) Multiple case studies were used in the study, which is well established and backed by multiple recognized researchers in the field c) Data triangulation was employed. This strategy made it easy to cross check the findings with different data sources. For example, data from interviews were triangulated with observations and secondary data d) Respondents were given the opportunity to withdraw from the study at any time. Only genuinely interested respondents were chosen to collect the data e) Peer debriefing: the researcher has continuously taken support and feedback from his peers. The researcher attended seminars and conferences to and taken on board suggestions and critiques. The researcher was also part of the Resilient Organization, New Zealand which provided support during this whole study.
<u>Dependability (Reliability)</u> It refers to the stability of results over time.	a) Detailed interview protocol was prepared to collect the data. This protocol includes a description of the research, concise questions about the phenomenon and has a complete list of prompt questions asked during the process. This can help future researchers to follow the same procedures to get similar results
<u>Transferability (External Validity)</u> The level to which results from one case study or real world can be applied to other case studies in a different context	a) Provide thick description: Thick and detailed descriptions are provided for each case study as well as the setting/context with in which this case study was embedded b) Multiple case studies are done in similar conditions which further enhances the transferability of this study c) Purposeful sampling was used, and it helped the researcher to stay focused on the key informants. It helped the researcher to collect in-depth findings
<u>Conformability (Objectivity)</u> It refers to the degree to which results from one case study can be confirmed by other researchers	a) Full details of the participants were collected in the process. Participants were also given chance to read and give feedback on the transcripts. Similarly, the interpretation chapters also includes quotes from the participants' interviews

3.13 Summary

The research process, the use of the case study method data collection process and techniques used for data analysis have been explained in this chapter. The whole research design (the choice of the case study method), the selection of four cases, the philosophical stance and data collection from two regions with specific disaster profiles, emerged from the research questions and the conceptual framework. The following two chapters (Chapters Four and Five) provide background information about the research context and the rich case descriptions.

Chapter 4

The Research Context

4.1 Introduction

To better understand the analysis, it is imperative to describe the context of this research, both in terms of the two regions (their demographic profiles) and disaster profiles.

As noted earlier, South Asian countries are particularly vulnerable to natural disasters (Douglas, 2009; D Guha-Sapir, Hoyois, & Below), that have long-lasting effects on the economies of these countries (Mirza, 2011). These are frequent floods in Pakistan and India and/or earthquakes in Nepal and the Himalaya region. As these countries rely predominantly on agriculture as a key component of their economies, they all experience similar problems of food security, low fertilizer rates, crop diseases, logistical problems and labour issues (Joshi, Gulati, Birthal, & Tewari, 2004). This research is centered on Pakistan as it is the second largest country in South Asia, both in terms of population and area (Division, 2011). With the total population (approximately 200 million), spread across the four provinces, the economy of this country is the 47th largest in nominal terms and the 27th largest in the world in terms of purchasing power parity (Swathi, 2015).

Pakistan is a member of the United Nations (UN), the Commonwealth Countries, South Asian Association for Regional Cooperation **(**SAARC), the Group of 24 and the G20 developing countries (FAO, 2016). Islam is the predominant religion of the country, yet the regions consist of multiple ethnic groups. Urdu is the common language which is spoken by most of the population, however, people of the sub-regions hold tightly to their own dialects, ethnicity and cultural values. The two main ethnic groups are Punjabis and Pushtoons, which make up of 44.1% and 15.4 % of the population, respectively. (S. Shah & Amjad, 2011).

Politically this region is fairly unstable. The military appears to be the major stabilizing influence in the country, for good or ill. As such, it has seized power many times through military coups, which has only added to the instability of the political system. Further, political parties are riven by corruption and lack any accountability, which adds to the chaotic situation in the region. Indeed, the war on terrorism led by the United States has exacerbated the perplexing situation even further (Gortney, 2010). Some of the major problems in the political

system are bribery, bypassing the rules and procedures, favoritism, illegal appointments, smuggling, black markets and the abuse of power. While heavily censored, everyday media reports and surveys show that a large number of political stakeholders, top bureaucrats and bank executives are involved in financial irregularities in the region (Fair & Gregory, 2016).

The region is vast and possess abundant natural resources. It consists of numerous ecological and climatic zones, ranging from mountains in the North to deserts in the South. Due to its rich climate, this region has great potential for producing all kinds of crops and other food commodities (Raza, 2014). As agriculture is the most important sector of the economy, it is the foundation for continuous growth of the country. Agriculture's contribution to the total economy is around 21% of the total GDP. Forty-five percent of the labour force is directly, or indirectly, associated with this sector (Bashir (2010). The contribution of agriculture in the region can be seen in three different ways. Firstly, it provides food for the local population. Secondly, it is also the main source of foreign exchange earnings. Thirdly, this is seen as the main buyer of input industrial goods. In Pakistan, more than 60% of the population live in rural areas and they earn their livelihood from agricultural activities such as farming, livestock, labour, transportation or wholesale markets (Division, 2011).

4.2 The Punjab Region (R1)

Punjab is the largest province in Pakistan. It covers more than two hundred thousand square kilometers of area and is located along the northwest edge of India, with whom it shares the Punjab region. The region is named after the five major rivers that flow in the region, therefore making it one of the most fertile areas for horticulture in the world. The canal irrigation system is the best in the country and most of the population is associated with agriculture. Weather is of an extreme nature, being extremely hot in summer, with heavy monsoons in the later-half of the summer season and being very cold in winter with hail, snow and fog creating problems for everyone (Ahmed, un Nisa, Akram, & Sami, 2015).

The province has the highest population density with around 359 persons per square meter. In Punjab specifically, around 70% of the population lives in rural areas while 30 percent is settled in urban areas. Although it has a dry climate, irrigation makes it a highly efficient agriculture sector. The major crops, wheat and rice, are two main staple foods for the whole country. Similarly, vegetables, fruits, corn, maize and sugarcane crop are also heavily

cultivated. About 70% of the total grain contribution of the whole country comes from this province (PDMA, 2008).

Punjabi is the regional language, yet it is a multi-cultural society, as people from all over the country come to find work and to take advantage of economic viability of this province. However, while it has many similarities, it is quite different from other provinces. One of the important factors in Hofstede's cultural framework is collectivism/individualism (Hofstede, 2013). According to S. Shah and Amjad (2011), Pakistan is very high in the collectivism index and especially the Punjab province. People are generally inclined to work in groups and believe strongly in group cohesiveness and expect loyalty. Indeed, law abidance here is better than in other provinces. Even though the gap between rich and poor is widening in the region, people have a greater tendency to accept the unequal distribution of power as compared to other regions. As such, smallholder farmers face significant hurdles when trying to access much needed resources.

The Punjabi people are risk intolerant and tend to avoid uncertainty. While it is mostly a male dominated society, women play an important role, especially in the urban areas. Most inhabitants are Muslims with moderate values and are less extremist in their religious views than other provinces. People tend to live in joint family systems where their day-to-day life is dependent on each other. The logistical and physical infrastructure is adequate in urban areas, however, in smaller towns and rural areas the quality of the infrastructure is poor. Energy is intermittent and has damaged the overall production and handling of agriculture products. In comparison to other provincial governments, the Punjab government is more stable and takes a greater interest in the development of the agricultural sector. Given the frequency of disaster events, they have established the Punjab Disaster Management office as the regulatory organization that controls all of the relief efforts in the Province.

This region suffers from heavy monsoon rain in summer and floods, while droughts in the eastern part are a major problem. Almost ten million people were severally affected by the 2010 floods when the Jhelum and Chenab rivers burst their banks and flooded the area. The floods destroy crops and damaged the infrastructure, that in-turn, directly affected the whole food supply chain in the region (Shabir, 2013). The food supply chains here are particularly vulnerable to natural disasters.

4.3 The Khyber Pakhtunkhwa (KPK) Region (R2)

This region lies at the junction of the three largest mountain ranges in the world; the Hindukash, Karakaram and the Himalyas. As it is geologically very active, it suffers frequent earthquakes, and is also vulnerable to flooding from melting snow and glaciers in the summer. The logistical and physical infrastructure is very poor and the sparse road network that winds its way through the mountainous topography is vulnerable to slips, rock falls and disruptions. The KPK region also shares its border with Afghanistan on the west and with Punjab province on the east (FAO, 2016).

There are twenty-five sub-districts within this region. The largest city and the capital is Peshawar. Other main cities are Noshera, Mansera, Mardan, Swabi, Mengora and Karak. The district of Peshawar, Mardan and Swabi are very fertile. Other hilly areas mostly grow vegetable and fruits and depend upon the rain fall which is quite frequent when compared to other parts of the country which tend to be quite dry. This region has a range of different climatic and physical conditions. On the northern side, heavy snow and rain happen throughout the year. About 16% of total population resides in this area. People are mostly associated with agriculture and the tourism industry. The total land area under cultivation is around 14 million acres, of which 22 percent is forest, 23 percent is horticulture with the remainder uncultivated due to a shortage of water (A. Khan, 2012).

The agriculture sector contributes nearly 40% of the region's GDP. The largest crops produced in the region are maize and wheat. However, the yield per-acre is far less than the actual potential because of the poor financial condition of the farmers as well as poor irrigation systems. Vegetable and fruits are cultivated extensively throughout the province. In the mountainous part of the region, these items are also cultivated in summer due to the cooler climate at altitude, thus most vegetables are available throughout the year. Culturally and religiously, the people in KPK are more conservative compared to the Punjab region. Yet, they tend to take more risks and believe in the combined (extended) family system and the importance of cooperative groupings. The culture of hospitality to strangers is a core heritage of the region, and most people are supported through a smallholder family businesses (S. Shah & Amjad, 2011). In terms of Hofstede's cultural dimensions, the KPK region attained a high score in the 'power distance' index; indicating that people accept the unequal power distribution. Also, people of this region are better in terms of long-term orientation as compared to other parts of the country. The culture is also very paternalistic with women

being mostly ignored in mainstream of life, with strong tribal and sub-tribe affiliations (S. Shah & Amjad, 2011).

In terms of logistical and physical infrastructure, this region lags significantly behind the other provinces in Pakistan. The people are poor and lack basic facilities. The dissemination of research and other latest agriculture advances are scarce. The province has long been subject to armed conflict and is a center of religious militancy in the country. The growth of terrorism and the international war on terror has made this region far less attractive for local and international investors (A. Khan, 2012).

4.4 Disaster Profiles of Regions 1 and 2

Pakistan is vulnerable to all types of climate-related natural disasters, mainly floods. Being at the intersection of the three highest mountain ranges, earthquakes are also very frequent. The total number of people exposed to the floods in Pakistan is the highest out of the five South Asian countries. These floods occur annually due to the monsoon rain system that originates from the Bay of Bengal, crosses over India, enters Pakistan and continues until it arrives in Afghanistan. The three mountain ranges in the north of the country thereby provide a perennial source of heavy water flows in the rivers. Due to the lack of dams and the insufficiency of flood control measures in the country, heavy rain and the melting of snow and glaciers in summer results in regular heavy flooding in the region. Flooding mainly affects the Punjab and KPK provinces. Indeed, while there is a long history of floods in the country, the 2001 floods were more devastating than normal due to an increase in urbanization and ongoing climatic changes. In 2003, heavy rains and flash floods created havoc in the Sindh province, causing damage in the major urban centers and resulting in nearly 500 deaths. Similarly, in 2007, the KPK region was seriously damaged by heavy rains and melting of snow. More than a hundred people died and thousands more were displaced. Large areas of agricultural land were affected and the whole region was devastated both physically and financially. From 2010 to 2015, every year brought more flooding, but especially in 2010 when the floods in this region became one of the largest disasters in the world. More recently, the economy and population were badly hit by the 2014-2015 floods across the KPK and Punjab regions.

In more detail, the 2010 floods began when rain started falling in the middle of July breaking 80 year-old records. More than 200 millimeters of rain fell on KPK and Punjab in less than 24

hours. In Peshawar alone, around 300 millimeters of rain fell. This resulted in high flooding in the Indus river basin that killed almost 3,000 people and affected 20 million other people, of which over one million people were displaced (Kirsch, Wadhwani, Sauer, Doocy, & Catlett, 2012). These floods destroyed bridges, roads and other infrastructure in the KPK region. At the start of August, these floods reached the Punjab region as well, and destroyed 1 million acres of cropland there (wheat, rice, vegetables, sugarcane and cotton), and as a result, the economy was severely damaged. Structural damage was estimated to be around USD 5 billion, while agricultural damage was calculated at a further USD 5 hundred million. The total economic damage to the country was USD 40 billion dollars, a heavy burden for a developing economy.

Similarly, in 2014 and 2015, more disastrous floods (due to heavy rains in Kashmir and other KPK regions) created havoc in the country. Five hundred people died and more than eight thousand villages were damaged. More than two million people were affected and the economy was hit with another bill for USD 500 million for relief and recovery efforts.

In terms of seismic events, Pakistan is situated on an active belt and therefore faces frequent earthquakes of medium to high intensity. As noted above, the KPK region is especially vulnerable. Two recent earthquakes were significant in terms of losses to the country. The first notable earthquake was in 2005, and other is the more recent 2015 earthquake sequence. The word sequence is most appropriate, for there is never just one earthquake, rather the main earthquake is typically followed by thousands of aftershocks, many nearing the intensity of the main event, each causing further damage, fear and affecting the morale of the population. Both of these events are well remembered by the local population and will form the basis of data collection in the KPK region.

In detail, during the first week of October 2005, a 7.5 magnitude earthquake hit the northern areas of the KPK region. The earthquake was shallow at only 16km depth and destroyed hundreds of villages and towns. It killed almost 100,000 people and severally damaged the infrastructure and economy. The homeless were in the millions, and after a decade, people are still suffering from the direct effects of that earthquake (Hussain, 2017). The more recent 2015 earthquakes also happened in October. This one was again a large magnitude 7.6 event, at a depth of 150 km, resulting in than 200 deaths in the KPK region, and major infrastructure damage. Twenty thousand houses were damaged, numbers of people became homeless and

hundreds of people were injured. International relief efforts were severely constrained due to the mountainous terrain and destroyed roads and bridges which left communities cut-off for weeks on end (Swathi, 2015).

All of these events had a direct effect on the population, agriculture and the food supply chains of each region. How these supply chains prepare and respond to such disruptive events is the subject of this research, and the businesses that have lived through these regular and severe disasters are the respondents, and as such, the main reference point for the data analysis that follows.

4.5 Summary

This chapter has introduced both regions and their disaster profiles. Floods are more frequent in region 1 (R1), however, region 2 (R2) is prone to both earthquakes and floods. The following chapter provides the rich case descriptions of the four cases in the two regions that will ultimately lead to main analysis part of this research in Chapter 6.

Chapter 5

First Level Analysis: Case Descriptions

In this chapter, descriptions of each case study will be presented. Each starts with a generic description and identifies the main actors involved in each supply chain. Further discussion revolves around how these supply chains work and what the main processes are in each of these chains. The results are organised and discussed by utilizing the first level process, of the SCOR (Supply Chain Operations Reference) model (Supply Chain Council, 2008). The SCOR model is a process reference model for supply chain management and has been used by researchers (Huan, Sheoran, & Wang, 2004; Jbara, David, & Alpan, 2015; Ntabe, LeBel, Munson, & Santa-Eulalia, 2015) and consultants (Camirenelli & Cantu, 2006; Kasi, 2005) extensively, especially for its common terminology and uniform standards. This model can be used to explain complex supply chains using a set of common definitions (Jbara et al., 2015; Supply Chain Council, 2008). The SCOR model is organized around four main supply chain processes of plan, source, make and deliver. These are further divided into sub-processes, tasks and activities with each level providing further details of the business processes down to individual actions (Huang, Sheoran, & Keskar, 2005). Once the supply chains are explained through these main processes and activities, then activities can be further streamlined to enhance overall supply chain performance (Lin, Chen, Tsai, Lai, & Huang, 2005). In this study, SCOR level one process categories are used to describe the four supply chains in order to maintain consistent descriptions throughout.

This chapter will describe four supply chains in the two chosen regions. Each section begins with a brief overview of the respective supply chain. Further, all the main actors are introduced. Lastly, different processes related to planning, sourcing, producing and delivering will be described at each tier of the supply chain. The rationale for this organization is to facilitate case comparisons in Chapter 6.

5.1 Fresh Produce Supply Chain – the Punjab Region (C1R1)

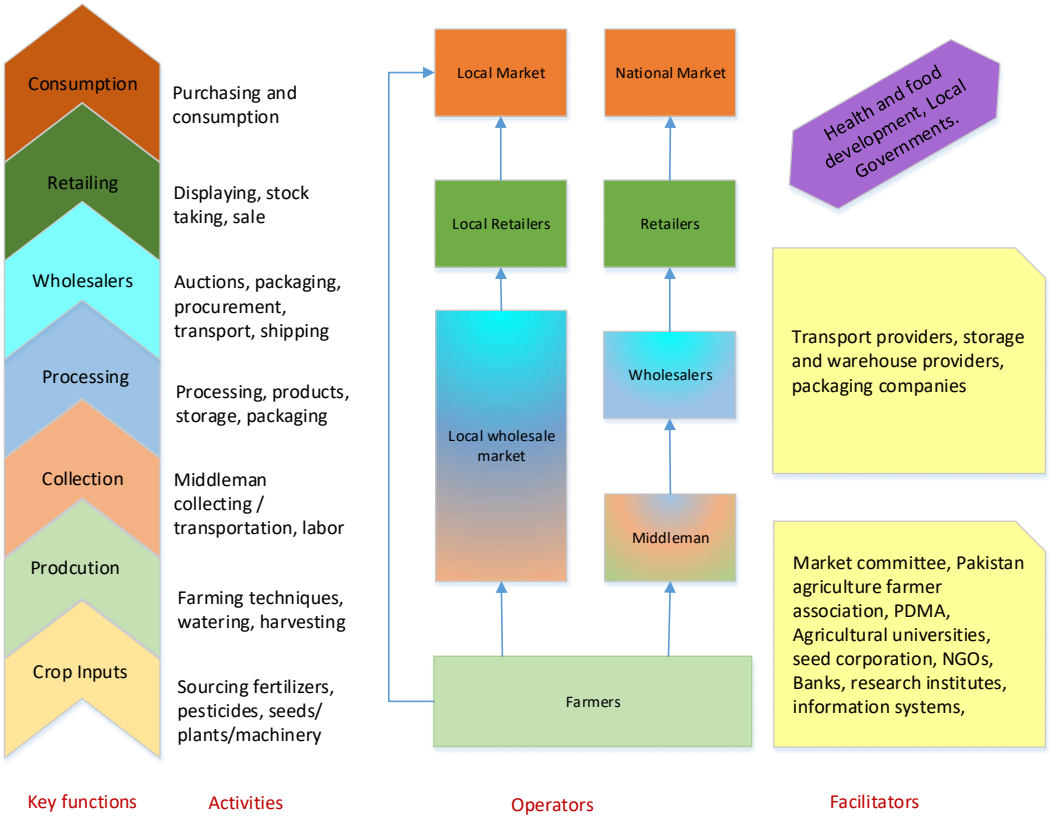
The following is a brief overview of the whole supply chain. The fresh produce network in the Punjab region is fairly diversified, with several different stakeholders, ranging from farmers, the private sector, to government actors throughout all of the tiers. These supply chains are

fragmented, to the point where it is sometimes hard to distinguish between different supply chain actors. In Punjab, these can be very complex chains with a number of different actors and hundreds of marketing channels to the final consumer. However, these chains are dependent primarily on the wholesale markets which are overseen by the local government and a market committee.

While Pakistan produces almost 10 million tons of fresh produce annually, only a small fraction of this is sold locally and consumed in homes. Most goes through a complex supply network to reach to end consumers. There are over 300 markets in the Punjab region which take part in this system. These wholesale markets are the central features of these chains and all suppliers and buyers are connected through these hubs. The commission agents and 'Pharia' (smaller wholesalers), are key stakeholders within these markets.

This supply chain starts from the farmer who grows the vegetables and fruits. These farmers either bring these items directly to the market, or, more frequently, a middleman is used. It is common for fresh produce to be delivered via third-party transport providers. Labour is generally inexpensive and is hired locally. In the market premises, commission agents sell the products through auctions, to wholesalers and directly to big retailers. These wholesalers have connections with small wholesalers and other small and big retailers, and through these retailers, items reach the end consumers. The government plays an active role in setting the prices and regulating the behaviors of the markets. There are other stakeholders such as research institutes, storage providers, waste management companies, exporters and packaging material providers that are also part of these supply chains, who interact at various tiers.

Figure 5.1 C1R1 Product Flow Along the Supply Chain



Source: Developed by the Author

5.1.1 Supply Chain Main Actors

5.1.1.1 Wholesale Auction Markets

Wholesale markets are the building blocks of these fresh produce supply networks in the Punjab region. These markets are traditionally established by the provincial government. Within these markets, commission agents are the main stakeholders and they are allocated spaces for shops which they build using their own investment. Wholesalers and small retailers are not allocated any space; nonetheless they are the second most important actors in these markets. Commission agents sub-let (rent) these smaller wholesalers and retailers' space in order to conduct business that the commission agents are so dependent on. The marketing committee also has an office allocated in the market. There are three clear types of wholesale markets; the largest one covers the whole district, the next smallest is at the town level and the smallest ones exist at the village level. Not every town or village has a market, rather these

markets are strategically built to cater for the needs of different areas. All of these markets are linked to each other, (that is, the town level markets are dependent on district level markets for their supplies). Although they get some of their supply directly from the middleman and farmers, the bulk comes through the district markets. Similarly, village level markets are mostly used to package different items and to make them ready to supply to district or town level markets.

Once the fresh produce arrives in these markets, it is traded on the special auction floor where all the wholesalers and retailers assemble. They quality check (visual and physical examination) the products on the spot and based on anticipated demand, preference and quality, they place their bids.

Within the large complex supply network, these wholesale markets are the most important nodes, as all of the business runs through them. All of the other nodes tend to attach themselves to these central wholesale market nodes. Within these markets, there are hundreds of relationships that exists between different actors, who are all part of these complex markets. Within this market node, each individual has their own specific goals of demand and supply, but they are also part of network level goals of the market, set by the market committee a phenomenon is referred to as a 'network administrated management' (Provan & Kenis, 2008). These markets also possess another important property of efficient supply chains, which is power law distribution, as there are only a few very large nodes in the whole supply network that have the vast bulk of the links within the network (Barabási, 2009). These district level wholesale markets are the channels leaders and play a central role in network wide control and coordination of the supply chain. These markets can be thought of as a single large firm (quasi-firm) with different departments such as commission agents, all owned and working independently, yet connected to each other through frequent transactions and a common governing body.

The resilience of these hub nodes stems from their size, myriad connections and flexible structure. Even if some of the nodes are removed during a disaster, the node and network keeps on working, as hundreds of different connections are made and removed in the process. However, if something dramatic happens to the wholesale market hub node itself, then the whole network system becomes disturbed. This was seen during the recent floods when the wholesale markets remain closed for few days. This resulted in the loss of a large amount of

fresh produce and revenue. Within these wholesale market, there are three main actors: commission agents, wholesalers/retailers and the market committee. Each is examined below.

5.1.1.1.1 The Commission Agents (CA)

Commission agents are pivots in the market. They act as the key link between producers and the consumers. They sell products on an open auction basis in the wholesale market on a daily basis. For regular customers, they sometimes negotiate a direct price, thereby bypassing the auction system. Each commission agent usually has a portfolio of regular wholesalers with whom they consistently trade, hence they develop good working relationships over time. Their offices are situated internally to the market and they lease this space off the government. Within their offices they have usually 3 to 5 staff members. One of the main staff roles is the salesperson who is responsible for keeping records of all the transactions and a sales register. This person has control over the flow of money, credit transactions and other day-to-day expenses. There is also usually someone in the role of manager, who oversees key office tasks, administration, assets, and vehicles and manages all of the other staff members, including contingent labour. There is also usually a contractor who deals with the farmers, other suppliers and customers on behalf of the commission agents to negotiate over financial contracts.

Commission agents hire their own labour as needed from the labour unions present in each market. They pay them cash on a daily basis. This labour is responsible for all of the material handling and physical work in the wholesale markets, such as using small carts to deliver fresh produce to the auction floor from the storage area. These storage areas are also maintained by the commission agents.

5.1.1.1.2 The Wholesaler (WS)

The next most important actors within these wholesale markets are the wholesalers. The wholesalers also work as retailers and usually rent space for their operations from the commission agents. They have strong connections with the retail market, cart sellers and other superstores (large supermarkets). They mostly buy their fresh produce from the commission agents at auction (if not a direct purchase) and then on-sell to the open market. They also hire their own labour to transport produce purchased at auction, from the auction floor to the respective sorting places of these wholesalers. Here the produce is further divided

into smaller lots or according to customer demand (and/or packaged). When the produce is released, wholesalers transport the goods to the buyer's premises and from here onwards, it is the buyer's responsibility to manage the stock.

Wholesalers know the actual demand and prices in the market. Prior to the auction, they have already collated orders from retailers and other smaller wholesalers. In short, they are in touch with the market forces and act accordingly.

5.1.1.1.3 Market Committee (MC)

The market committee is an institution established by the government to manage and regulate all of the vegetable and fruit markets in the province. There are a total of 135 market committees working in the region, for both fresh produce and grain markets. This also means that the entire province is divided into 135 segments which are regulated by these market committees. Market committees are classified based on their revenues. There are three classes of market committee; those that generate revenue of more than USD $15,000 per year are categorized as 'A', those between USD $8,000 to $15,000 are categorized as 'B', and below USD $8,000 are considered category 'C'. This revenue is generated predominantly by market fees charged to the commission agents, as well as logistic providers and stakeholders. It is also generated by the issuance of licenses to commission agents for running businesses in the market and also through infringement notices and fines issued for violations (such as delivering poor quality products).

'A' and 'B' category markets are comprised of seventeen members. These members are made up of; farmers, commission agents, one government appointee, and one consumer. Similarly, 'C' category has ten members. The main duties of these market committees are to enforce the laws of ordinance and rules set by the government related to price, supply, demand and safety. They are also responsible for establishing prices for all products based on historical information, quality and supply. They issue licenses to different stakeholders and are also responsible for the housekeeping and maintenance of the wholesale market place, including all of the buildings. They provide facilities to build the storage spaces that directly benefit farmers. A key function of these market committees is to act as a mediators/facilitator and resolve any disputes among the different stakeholder. As such, they have a strong influence on the social and behavioral climate of the wholesale markets.

5.1.1.2 The Middleman (MM)

Due to a lack of knowledge and expertise related to price, logistics, and market functionalities at the farming level, fresh produce farmers frequently depend on a middleman to take their products to the wholesale market. The middleman is a key link and facilitator of information and resources between the farmer and the commission agent. The middleman possess superior local knowledge about their area, soil type, the farmers, farm practices and keep a keen eye on the crop as it develops. Critically, they have the social network connections with key actors within the region's larger wholesale markets that they guard jealously. It is not that some farmers do not have the knowledge, sometimes farmers prefer to deal with the middleman to remain free of all the other problems associated with harvesting the crops, logistics and labour. Therefore, even in the more developed chains, middleman are the preferred link, rather than dealing directly with the market themselves. As the middlemen buy in-bulk and from a number of different farmers, they can achieve economy of scale that small farmers cannot achieve in isolation. As such, this increases the middleman's leverage with buyers at the wholesale markets. Indeed, if the middleman is taking a large share of the profit, they are also taking on all the risk.

5.1.1.3 The Farmers (Fr)

There are two main types of farmers in this region; those who own their own land for cultivation and those that lease or rent land, or small-holder farmers. Land owners typically have a much greater area for fresh produce growing, greater resources and hence can achieve a form of scale in their operations. As land owners, these farms are much more stable, durable over time and will often have direct network connections to the wholesale markets. Given their greater scale and resources, they possess a greater ability to absorb any negative effects of any disruption. They usually negotiate supply contracts from the bigger companies for their input supplies (such as fertilizers and seeds/flowers). They also have greater access to information from the research institutes and are better able to utilize extensions services and deploy better seeds and cultivation techniques. Typically, these land owning farmers will be people of standing within the community and influential in the markets, and through family and commercial connections, can influence the local and central government on legislation.

Conversely, the second type of farmer are the small-holders. While some actually own their own land, many are forced to rent or lease land from the larger land-owners. Interestingly,

the bulk of the fresh produce is grown by these small-holder farmers. It is these famers who face significant difficulties in bad weather or during some natural disaster or other disruption in the chain. As such, they often deal with the middleman in order to connect with the market and to pass on the bulk of the risk. These middlemen will also help them with fertilizers and other equipment for cultivation and harvesting.

5.1.1.4 Retailers (Rt)

Retailers in the region can be categorized into three main types, based on the volume. The first category are the superstores or supermarket chains. These larger organizations procure fresh produce directly from the wholesale market. However, as they need high quality and standardized products, with consistent taste, texture and presentation, they have their own department for quality, and it is these representatives that deal with the wholesalers. A number of the superstores also have direct links with some larger farmers that supply exclusively to these stores. They invest in these farmers to ensure quality and high standards of packaging. Given the higher quality of the fresh produce and the overheads of these superstores, the prices asked for their fresh produce is greater than bought through other channels

The second category, and the most common one, sells fresh produce to the end consumer from small, to medium, retail shops throughout the province. They purchase fresh produce either directly from the wholesale market (auction) or from the local wholesaler. They usually have their own transport assets to stock their own shops, according to their demand. Importantly, they also provide market information back upstream that is derived from consumer preferences about taste, size, and quality.

The last category are the small-cart business retailers. These are clearly low volume small scale operations and buy their produce from the smaller wholesalers at the market. They sell to consumers from their carts alongside busy roads, other markets and bazaars. They mostly buy cheaper and lower quality fresh produce not wanted by other retailer channels and therefore have lower prices as compared to the shops. They work on a day-to-day basis and sell seasonal products or what product is in demand or on-hand. While low scale, their operations are quite flexible and adaptable and can quickly shift locations and products with little disruption.

5.1.2 Supply Chain Main Processes

Having now discussed each of the main actors, the focus now shifts to analyzing the main supply chain business processes. These are discussed according to the categorization of the SCOR model.

5.1.2.1 Planning

The key demand planning activities of the supply chain happen in the hubs (wholesale markets) where commission agents plan the upstream and downstream side of the network. While all of the other stakeholders conduct their planning as well, the key signals emanate from the commission agents. Most of this planning takes place two three months before the start of new season. Forecasts are also done, mostly for the next coming season.

Here they collect the data about different supply sources. This process is conducted with the help of middlemen who physically visit the villages, famers and landlords, as they are better placed to provide key information as to the crops, timing and other coordination and price issues. They also assess the financial position of the farmers. This financial position is important as commission agents invest in these farmers and are concerned about the financial viability of farmers.

Commission agents also have their own representatives who visit potential suppliers in the field and collect data regarding the suitability of the source. Each commission agent specializes in only a few different commodities and hence has a better understanding of the particular season and demand in the market. Aggregation and demand prioritization is another process which runs parallel with the supply source suitability. This information is collected through the agriculture information system website setup by the government, as well as information gathered from small wholesalers who are directly linked with retailers in the market. Calculations about final customer demand is also based on the aggregated weighted average of the last seasons. Some of the big and more stabled commission agents have their own statistics teams who calculate the predicted demand based on the latest technological software.

In addition to demand planning, inventory planning also occurs. Outputs of this planning include calculating required storage space. While some commission agents own their godowns/warehouses, when they are short on capacity, or any agents who do not own

warehouse space, will book or lease warehouse space from others. They also decide what to do with any excess inventory post-harvest and will utilize alternative distribution channels, such as the Sunday bazaars that are organized by the government. Hence, commission agents depend on planning data, albeit forecasts, to plan capacity and book space and bazaars in advance. However, this clear planning is only seen in the case of well-established and financially strong commission agents. Many other agents rely on this information, which in most cases is only partially shared. There is lack of consistency and standardization in this planning. Many times, it is just an informal process with distorted data.

Alternatively, middlemen collect their information by personally visiting the farmers and landlords. Based on their experience, they evaluate the suppliers. They deal with the logistic companies who transport products from the farm to the wholesale market. Most of the time, they sign the contracts with a few logistic companies, while on occasion, due to their local knowledge, they will rent vehicles from the area. They also negotiate with the local labour representative to supply labour for harvesting and to pick the fresh produce items once ready. Concurrently, on the demand side, they deal with various commission agents in different markets to evaluate the options given about the expected quality and quantity of the produce. As they do not have their own storage space or a physical office, they depend heavily on the commission agents for their planning. Many times, both commission agents and middlemen indulge in joint collaborative planning. This means they help each other in forecasting consumer demand and also the supply side of production. Commission agents have the local connections and farmers can sometimes deal directly with the commission agents. These planning activities are a key part of the supply chain coordination and help build collaboration and social norms. Interestingly, both use this information to assess the sustainability of sourcing and the long-term benefits.

At the farmer level, planning includes making decisions about what seeds and plants to buy. Many times, farmers use their own plants and seeds that they have gathered from special cultivated crops. However, at times, they will plan to source these from the market. They trade-off the costs and benefits of both sources based on local trends and accessibility. Similarly, for fertilizers and pesticides, they collect information from the dealers and the Punjab Agriculture Information Department (the provincial Government department responsible for disseminating information related to agriculture), according to the latest diseases related to the crops. The critical planning is about the latest trends and demand for

particular products. This data is collected from the wholesale markets that they often visit, as this is the main source (hub) of all the information (all of the stakeholders interact there). Another basic element of this resource planning concerns the labour requirements and equipment needed for any particular season. Water management is also planned along with other farmers. Sometimes when canal water is not available, farmers plan for their own water resource by building tube wells in the fields. This type of planning is also known as 'rough-cut capacity' planning where farmers compare the actual capacity to the required capacity, and then reconfigure their resources accordingly.

At a more strategic wholesale market level, planning also occurs among the market committees in terms of setting the price of commodities. This is based on the data available to them concerning product cost as well as according to supply and demand levels. Last season's prices are also considered here. Product quality and the product's origin also contribute towards the final price. They also plan the overall maintenance of the market and determine storage space allocation according to stakeholders' requests present in that wholesale market. Planning is not done in isolation, but includes input from commission agents, middlemen and larger farmers.

Wholesalers also generally plan for the labour needed. They collect the information from commission agents and those farmers who frequently visit the wholesale markets. As they are also linked with the end retailers, they are in a better position to forecast the actual demand for the upcoming season. They take the orders in the planning phase (that is, two to three months in advance before the start of next season), and also deal with the super stores and plan for the packaging standards and requirements. On occasion, training is provided to the labourers by larger retailers, and covers different aspects of quality and standards needed for each product. Small retailers mostly plan their need for transportation (to get the products from the wholesaler to the markets). Superstores have a whole separate department for supply chain planning. Their representatives visit different markets and farmers to collect data about the products. They check the sustainability and quality standards of their potential supplies. Within the store, they make plans for warehouse storage and inventory management according to the demand and season.

There are many interesting aspects in this planning category which are worth noting, such as sharing information, training supply chain partners and working together to solve problems,

like installing tube wells by groups of farmers. These elements are discussed in terms of resilience in the following chapter.

5.1.2.2 Source

The next major process is sourcing or buying. Major sourcing is done at the wholesale market level. Commission agents select their sources/farmers based on the recommendations of middlemen. They select the best possible sources, based on the demand they anticipate for the following season that is mostly two to three months in advance. The larger farmers and landholders bring their products into the wholesale market to their specific commission agent. The vehicle enters the market through a specific route and at the entry they pay market entry fees to the market committee. The commission agent staff samples the quality of the product by opening the packaging of few products as most business is based on mutual trust. From here, either the product goes directly to the auction floor or it goes into the storage spaces, where further processing is done, such as sorting and repackaging. Sometimes payment is made directly when the products are received. However, most of the time, collaborative efforts are seen in the wholesale market as commission agents have already invested in the farmer, and transactions are processed accordingly. Investment is sometimes provided directly (through giving loans to the farmers), or through the middleman, as this person is more familiar with the farmers. This arrangement is interesting in terms of resilience and will be discussed further in the following chapter.

For the middleman, sourcing refers to the procurement arrangements they have with the farmers directly and also for the labour and logistics (transport) arrangements to get the product to the wholesale markets. They arrange for transportation to collect goods from individual farmers. In general, products are packaged into bundles or in special crates and this happens early in the morning as fresh produce is highly perishable. In addition, the wholesale markets also operate in the early morning, hence collection is done in the first few hours of each day. Farmers carry the crates to the side of main road and from there, it is collected by a small truck. If the middleman has already taken the ownership of the crop while it was still in the field, then they are also responsible for the harvest and logistics to the markets. In this case, the labour costs and all other surcharges are the responsibility of the middleman. The middleman is also responsible for quality inspection when it leaves the farm, but as they have kept a close eye on the crop all season, this step is often dispensed with.

Farmers procure their supplies from the wholesale market; they arrange their own transportation and bring the pesticides, fertilizers and other supplies to their fields. Smallholder farmers rely heavily on the same middlemen who take care of their crops for the supply of the fertilizers and pesticides. The middlemen work in different ways; sometimes they buy the whole field from farmers before harvesting and other times they just lend them finance. Here middlemen, and sometimes commission agents, play a dual role of buyers of crops from farmers, as well as suppliers of fertilizers to farmers. These dual roles depend on full market information, years of experience and easy accessibility to multiple businesses in the wholesale markets. In terms of supply chain resilience, these elements contribute significantly and will be discussed in the next chapter. The landlords and larger farmers have direct connections with the supply companies who often deliver goods to their customers.

Upstream wholesalers procure their fresh produce from the auction floor at the wholesale market and take it to their respective storage space in this market, utilizing their own labour. They inspect the product and compare it with several other commission agent's offerings who have experience of being in the same market, and by word-of-mouth. They pay immediately on the same day to the commission agent, farmers and middleman. Similarly, retailers use their own transport to pick up the ordered quantity from the wholesale markets where they inspect each packing. They are occasionally present at the auction floor as well, where based on the price and quality, they select their wholesaler. Superstores have their separate systems of sourcing, as their standards of quality and packaging are high. As they have already trained their representatives, they make sure they are getting the right quality. They purchase from several sources, the auction, the wholesalers, or directly from the larger farmers under contract. They have their own special transportation which picks these items either from the wholesale market or directly from the farmers.

5.1.2.3 Make

In these fresh produce supply chains, the major 'make' decisions are related to production at the farmer level. At wholesale market level, many of the 'make' decisions are just related to the packaging and dividing the products into smaller batch. Some of decisions are also related to storage where goods are divided into small batches. Here, fresh produce is generally divided into three different qualities; high quality, medium and low quality. Most of the vegetables are then taken to the auction floor for immediate sale, while fruits, such as mangoes and bananas, are taken to large storage houses for further ripening.

Farmers make many decisions in this phase. These include fields to use, crops and varieties to plant. The application of fertilisers, irrigation and the many other decisions that are needed to successfully produce commercial fresh produce are also made in this phase. The actual farming practices themselves are outside the scope of this thesis and are hence only superficially addressed. The harvested produce is initially graded at the farm and then again at the wholesaler and retailer's levels, a further division of products into smaller batch and packaging is also done.

5.1.2.4 Deliver

Physical delivery of products has already been discussed throughout in the previous three sections. However, the auction is one of the major processes that occurs in the wholesale market and without this process, the delivery process would not be complete. It is a transitional process between upstream and downstream physical delivery. The auction is the best place to promote and price the product. Similarly, buyers get information about wholesale and retail markets with latest trends. This is the best tool for measuring customer satisfaction about the last crop. This interaction among actors, and the sharing of information, are also contributing factor in supply chain resilience and will be discussed further in the next chapter.

The auction is conducted under the supervision of the auction committee present in the market. This auction is conducted at specific hours of the day (normally early morning). This timing is fixed by the market committee and notices are displayed throughout the market. There is a special place allocated in the market for this purpose and it cannot be changed without the approval of the committee.

The goods are usually auctioned based on weight, quality, number and lots of agricultural fresh produce. The auctioneer is the person licensed by the market committee who conduct this auction. This person is usually the representative of the commission agent. Before starting the auction, the auctioneer will announce the agent to whom the produce belongs to, then he will provide his registration number and name to everyone.

This person will describe the fresh produce in terms of the produce's common local name, origin of the produce, the farmer's name if possible, the date of harvesting, quality and quantity. The auctioneer will also announce the starting minimum price of the item which is set by the market committee, based on visual inspection, quality, current market price and

season. The opening price is normally set by the auctioneer, but as he is a representative of the commission agent, it is essentially dictated by them.

The person who is interested in bidding will provide his name and identity to the auctioneer. The item goes to the highest bidder. In most cases, bidding is open to everyone, while in some cases, it is confidential. However, in several other places it is a simple process of negotiation between sellers and buyers.

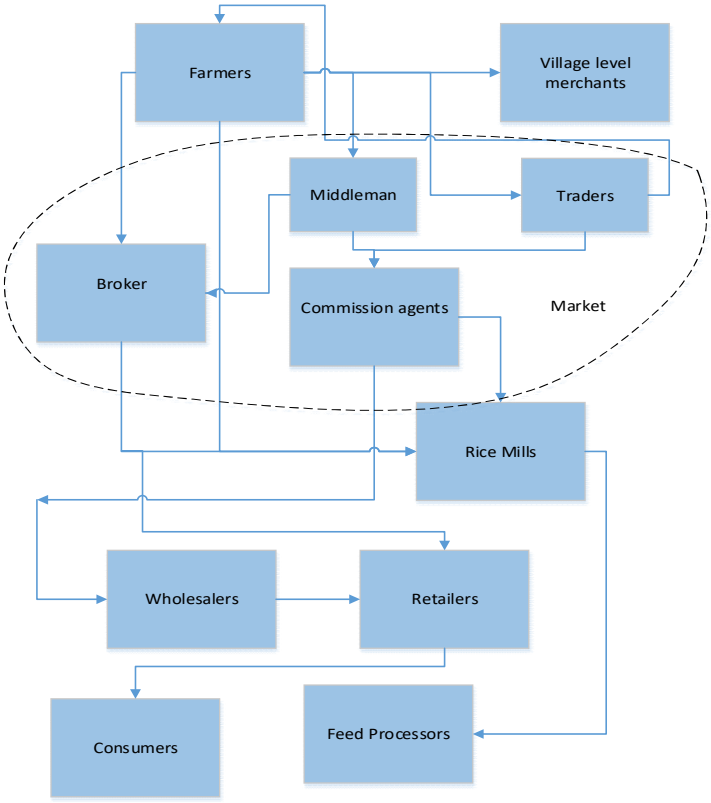
The successful bidder will submit the 25% of the total amount immediately to the agent and a receipt is issued on the official pad of the auctioneer. The due date for remaining 75% is negotiated between the buyer and seller. In the absence of such an agreement, the auctioneer will finalize the date.

From here onwards, small wholesalers and retailers use their own labour to take goods to their respective places within the market. There they sell it to retailers and place the required amount outside the market at a specifically dedicated place. From this point onwards, retailers bring their transport and take it away. The items which are not sold through auction are stored, and low-quality products are sold to the small cart shops at a lower price at the closing hours of the market. These alternative channels become very important during flood seasons when the quality of many products is low. There channels provide a 'cushion' in these cases and help the actors recover their investments. More details related to these substitute channels are included in Chapter 6.

5.2 Staple Food Supply Chain – the Punjab Region (C2R1)

Rice and wheat are the two main crop systems prevalent in South Asian countries, particularly in Pakistan and India (Sharma, Giri, & Rai, 2013; Sheikh & Abbas, 2007). According to the Pakistan Bureau of Statistics, these two staples cover almost twenty million hectares, with 50% of this area being in the Punjab province and 80% of farmers growing both crops (FAO, 2016; Rehman et al., 2015). Unlike the wheat supply chain (which is mostly controlled by the government at both federal as well as the provincial level), the rice supply chain is run predominately by the private sector and therefore, is better for our analysis. Hence, this case study will specifically focus on the rice supply chain network.

Figure 5.2 Product Flow in the C2R1



Source: Developed by the Author

Rice is a main staple food. Pakistan is a leading exporter in Basmati, which is a specialized rice, produced in India and Pakistan. Basmati rice is only cultivated in the Punjab region alongside the Jhelum and Chenab rivers. A traditional supply network is still intact in the Punjab region; it is a multistage supply chain system with different stakeholders at each level. This whole supply network can be divided into two main parts. One is where paddy is cultivated and brought to the traditional wholesale markets. This part of supply chain is dominated by commission agents present in the wholesale markets. The second part of this supply network is the processed rice supply chain. Here millers are the main actors and have a dominant role in this part.

Just like fresh produce supply chains, there are many actors involved in these chains (Figure 5.2). Farmers are the basic suppliers of paddy, progressing downstream come the middlemen, traders, commission agents, distribution agents, retailers and most importantly, the rice processors or millers.

5.2.1 Supply Chain Main Actors

5.2.1.1 Millers

Unlike the commission agents in the fresh produce supply network, rice millers are the main actors in this supply network. Rice mills are the processing units with the functionality of drying, husking and polishing the final product. There are almost five hundred mills currently operating in the region. Most of these firms are clustered near the major rice producing areas of Punjab such as near Lahore, Hafizabad, Gujranwala and Sialkot. It is a highly developed industry, with specialized machinery needed to meet international standards for processing. Smallholder farmers and other market actors who deal in paddy are dependent on these mills due to lack of drying and storage facilities. These firms also share their forecasting data about demand and supply with other actors in the network. They also have capacity to store buffer stocks for unforeseen events. These things are interesting in terms of resilience and are discussed further in Chapter 6.

These Mills generally represent a functional organizational structure with a number of different departments such as marketing, research, labour, human resource and production. As well as exporting different varieties of rice, these millers also supply the local markets and other local industries that are dependent on the by-products of rice. Millers procure the paddy from the local market, as well as directly from farmers, especially from the larger farmers. Most of the millers are also large farmers of rice crop themselves, having vertically integrated backwards or forwards, depending on their original position in the supply chain. They have their own governance structure with a range of different departments. There is also a Rice Association and the majority of the millers are members. The Rice Association negotiates with the government in times of crisis. Members also support each other in terms of finance or any other important resources. As most of these millers are also exporters, they are also often part of the Exporter Association. The Rice Association and the Exporter Association plays key roles in defining rice standards in this region. They also organize seminars and training session for farmers, millers and traders about the latest trends and techniques, problem solving, and managing bottlenecks in the sector.

The rice mills are at the centre of the information flows and are knowledgeable about the activities in the upstream supply chain, as well as the latest trends in the seed technology and

processing. Hence, they act as channel captains of these supply networks. They are also key facilitators of the flow of information to other supply chain partners.

5.2.1.2 Farmers

Farmers can be divided into two categories; those that own the land and those who rent out the land to small farmers. The one who owns the land is also classified as small-holders if they have less than 5 acres or large-scale farmers if they have more than 20 acres of land. Most of these farmers cultivate wheat and rice in rotation. Smallholder farmers use fertilizers and pesticides from input dealers present in the market. Many times, commission agents act as input dealers who have expertise and knowledge about dealing in multiple domains of the wholesale market. Large-scale farmers have direct contracts with the fertilizers and pesticides companies.

Large scale farmers have their own staff who help to cultivate and harvest the crops. Staff usually come from the respective villages of each farmer. Smallholder farmers bring their crops to the market through the village level trader or middleman. Large-scale farmers sell it directly to the millers. Most large-scale farmers also own their own mills and also export the rice to other countries. Smallholder farmers are most vulnerable to natural disasters; therefore, most government relief activities happen at this level.

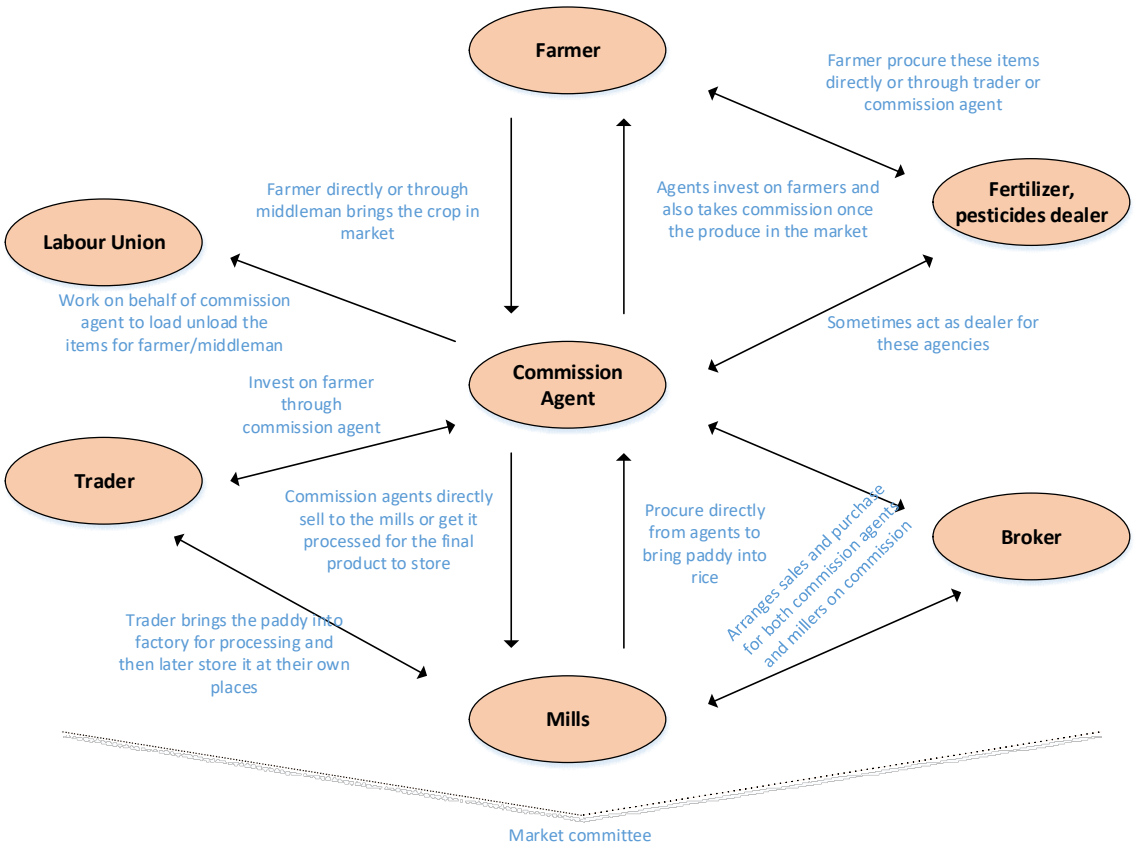
5.2.1.3 Grain Market

Another important node in the staple supply network is grain market. This grain market is operated on the same auction principles as the fresh produce market. There are currently 150 markets operating in the Punjab region which is looked after by 135 market committees. Market committee processes are the same as that explained in the first fresh produce network. The most important actors in these markets are also the commission agents who invest in farmers and establish a link between buyers and suppliers. As this market mainly deals in paddy, which is only the raw form of final product, processing units (mills) hold a strong position in this network. The interaction of actors is slightly different from fresh produce markets. The main actors in this market include commission agents, the middlemen, village level traders, traders, representatives of processing units, labour and the market committee.

5.2.1.3.1 Commission Agents

Just like the fresh produce markets, commission agents are the main actors in the grain markets. They have their own offices and places within the market. They have direct links to the farmers and the processing units. Farmers bring paddy to the market, either directly or indirectly (through middlemen). This comes to the auction floor where it is sold to the buyers. Well-established commission agents often buy the paddy directly from the farmer and send it to processing. They store the rice in their personal storage place and sell it in the wholesale market. Some of the commission agents also export rice to different countries.

Figure 5.3 C2R1 Interaction Among Members



Source: Developed by the Author

Commission agents have their own staff members who visit the farmers to check the quality of the grains. The rate of commission, fees and other processing charges are clearly mentioned in the government documents which are compiled by the market committee. They get the license from the market committee to operate in the wholesale market and this committee can revoke the license if something is above the law.

5.2.1.3.2 Traders

A very important actor associated with the wholesale market through the commission agent is the trader. The trader is the person who is financially sound and can invest in the famer through the commission agents' contacts. Sometimes they purchase the paddy directly from the commission agent and take it to the miller, where they process it. From there traders either store it at the storage house or supply it to wholesalers and superstores. Sometimes they supply to individual exporters as well.

5.2.1.3.3 Brokers

Brokers are the actors who finalize the deal between the millers and the commission agents. They have contacts in the mills and according to mill specifications, they supply the required quality/amount of paddy to these processing units. They have their shops on the outskirts of the market. Brokers act as a bridge between traders and mills for the supplies of rice.

5.2.1.4 Government

The government's role is critical in the staple food network. Firstly, they are the main stakeholder of the grain markets in terms of the market committee. They regulate and legislate the efficient running of these wholesale markets. They set the standards and rates as well as helping to resolve disputes among different actors.

The Government Seed Corporation and various research institutes put considerable effort into ensuring that they produce the best varieties of these crops. These institutes are funded by the government.

5.2.1.5 Others

From the mills, rice is supplied to the superstores and wholesalers throughout the Punjab region. These wholesalers are located in strategic location within big cities. Wholesalers directly buy from the mills, as well as from the traders. Retailers can be divided into small shops and superstores (which are only present in metropolitan cities).

Other than retailers, poultry feed processors also buy the by-products of rice and process it into feed which they supply to poultry farms throughout the country.

5.2.2 Supply Chain Main Processes

In this section, the focus shifts to analyzing the main supply chain business processes for major actors. These are discussed according to SCOR model categorizations.

5.2.2.1 Planning

The mills are the main hubs present in this staple food network. Major planning processes, which are part of a miller's business, are assessing and developing supply sources. Similarly, on the demand side, prioritizing and aggregating demand requirements are the main processes. Within the mill, planning revolves around the production unit, inventory and distribution requirements.

These organizations procure the raw material from the wholesale market and farmers. In other cases, mill owners have their own land, where they grow paddy. Each miller establishes close contact with brokers present in the grain market. These brokers are given quality and quantity details, along with price ranges at which mill owners will buy paddy. Similarly, millers have their own representative; they send them to the farms to evaluate the quality of the growing crop. They share their demands about quantity and quality with the famers. Sometimes they also invest in the farmers, so that they can secure the crop before it goes to some other channel. Millers have close relationships with seed corporations and other research institutes. They regularly interact with them to find out about the latest trends and implement those techniques in their own fields. This relationship building and following the latest research trends help them better prepare and respond to natural disasters. More detailed analyses of these practices are included in the next chapter.

These mills have also in-house demand forecasting departments which forecast the demand for the following year with the help of latest technology and statistical tools. They collect data from the Export Corporation of Pakistan, retailers and wholesalers. Similarly, they aggregate all of the demand from their downstream chain as well. This demand is compared against their own capacity, therefore reaching some rough-cut capacity of all their products and channels. The cooperation between both downstream and upstream actor is very important here. In most of the cases, there is mutual understanding and cooperation among these actors. This cooperation, knowledge creation and knowledge sharing will be explored further in terms of resilience in the next chapter. One thing worth noting here is that these activities are not done

as preparation for an unforeseen event. Nevertheless, these inherent activities within this network helps it to respond to disasters in a better way.

Mills offer training to their production and marketing teams. They arrange labour during this time as well. Labour is required to load and unload the material. Labour also provide assistant in dealing and drying the paddy. Millers also plan for production, servicing the machinery, electricity equipment installation due to power shortage issues and other manufacturing related issues. As they also have in house storage, they clean and maintain the place and move already held inventory to wholesalers and retailers. Mill manager regularly contact dealers and other downstream actors to assess current requirements.

They also plan the portfolio management based on the demand in the market. Linking to this process, two other critical processes are the product phase in and phase out process. They withdraw certain products and all associated processes with that product category such as sales, marketing, R&D and any other support. Similarly, for introducing new products new contacts are made. All other related sales, marketing and production departments are set accordingly. As compared to the fresh produce chain, processes in this chain are more specialized and advanced. This is due to the difference between the products. Rice has a longer shelf life and therefore is easy to manage. In contrast, fresh produce have very limited shelf life and is difficult to handle. More details are provided in the following next chapter.

Additionally, commission agents also make plans regarding the procurement and distribution. The processes involved here are more or less the same as described above for fresh produce related commission agents. These commission agents evaluate their suppliers based on the previous year's data and by arranging special meetings with the famers. They also help farmers to procure pesticides and fertilizers from the market. This dual role of actors was also seen in the fresh produce chain as well. Although being an inherited character in these chains, this feature contributes towards supply chain resilience. During the planning phase, traders from different parts of the Punjab region invest in the farmers through these commission agents. Therefore, they help both parties to connect and build relationship. Many commission agents get their paddy processed from millers and store the rice at the local storage facilities. They figure out the total capacity available in their storage space. This financial coordination among different actors is a key finding and helps farmers to recover quickly from natural disasters.

Quick recovery is an important element of supply chain resilience. The relationship between quick recovery and resilience are explained in the following chapter.

Similarly, as a basic entity of this supply network, farmers plan for production as well as transportation of their crop(s) to the market and millers. Famers can be divided into two main categories, large and small-scale landholders. Small-scale farmers have less capacity to produce; therefore, they deal with commission agents and procure pesticides and fertilizers from them. They also establish financial contracts with traders through commission agents. Farmers purchase seeds from the Seed Corporation and also organize their water requirements through local government departments or install their own tube wells. Small-scale farmers also need the equipment to plough and plant the fields. Most of them have contracts with the renting companies.

Large-scale land owners are more organized producers, as they deal with the millers and produce the crop according to their standards. They sign contracts and negotiate directly with the millers. They determine their total production capacity based on the nature of their fields. Similarly, they access different supply sources during the planning phase by their repute and quality of the products. These large-scale land holders deal directly with big companies to procure fertilizers and pesticides. They mostly have their own equipment; therefore, inventory planning is also part of this total plan. These large-scale farmers can be divided into organic farmers who do not use pesticides and fertilizers to produce according to export quality. In this case, the cost will be higher and productivity will be lower, but as they are in direct contract with millers and sometimes have their own mills, they are able to produce organic goods. The other one is inorganic farmers; they use both pesticides and fertilizers to increase their yield, and supply mostly the domestic market.

5.2.2.2 Source

Sourcing at the millers' level starts with the sample collection. There are different brokers in the market. After the necessary planning is complete, millers open the purchasing and announce it in the market through their contacts such as brokers and commission agents. These brokers collect samples from different commission agents and farmers. They show the samples to the millers and get approval. Once millers have established the sourcing quality, they order the required quantity. Most of the time it is the supplier's responsibility to bring the paddy to the factory. Once paddy is in the mill, it is unloaded at the designated place by

the labour. This paddy is packed in special sacks of the same size and weight. Before unloading, the quality checker evaluates the quality of each sack with special equipment through which they draw a sample from the sack. They check the moisture level and type of the paddy they have ordered. Inbound freight is given by the supplier but once inside the factory, labour and all other logistics, are the responsibility of the mill owner. They take the paddy to special dry storage rooms where it is stocked for further processing (to dry it or mill it immediately).

Other sources are the farmers who bring the paddy directly to the factory. Mills are in direct contract with them. They check the crop on a regular basis, throughout the life of the crop. Once it is inside the mill, the inspection teams once again check the quality and quantity of the paddy. After the inspection, the payment voucher is released.

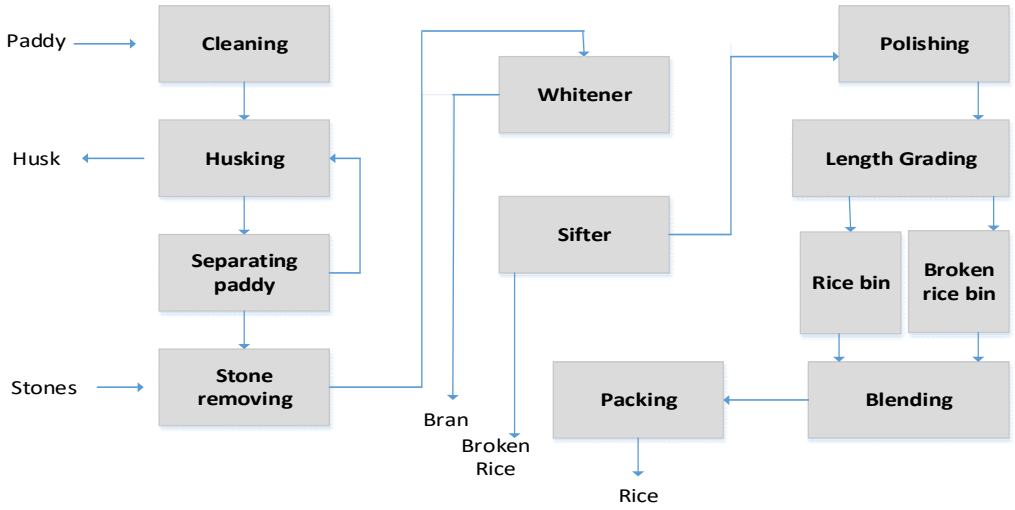
Within the grain market, the source processes are same as the fresh produce market. Farmers or middlemen bring their stock to the market, commission agents inspect the quality and bring it to the auction floor. Traders either directly invest in the farmers and they load the stock from the fields into the trucks or they take part in the auction and purchase it from within the market after inspecting the goods. At the farmers' level, small-scale farmers buy pesticides and fertilizers from the market while large-scale big farmers get their supplies delivered to their door by the big companies.

Retailers and wholesalers obtain the final product from the millers directly. It is mostly done through the brokers and traders in the rice industry. Once the truck reaches the warehouse, it is inspected and unloaded. Previous stock is rotated to a new position. If they want to store the rice for a longer period, then it is packed in special sacks which are airtight.

5.2.2.3 Make

Make processes are associated with the production processes at each node of the network. Major production is basically done at the mill and farmer's levels. Once mills source and receive all of the relevant material then production starts. First of all, the paddy is dried using both mechanical and manual procedures. Manually, paddy is dried in the open fields under the sun and once the required moisture is achieved, then it is taken to the production place. At some big factories, there are special driers which reduce moisture to specific level. Within the mills, husking, polishing, grading, cleaning and packaging are done. Based on the order, different types of rice are produced. These packages are thus carried to the storage space to deliver to the wholesalers.

Figure 5.4 Rice Mill Main Processes



Source: Developed by the Author

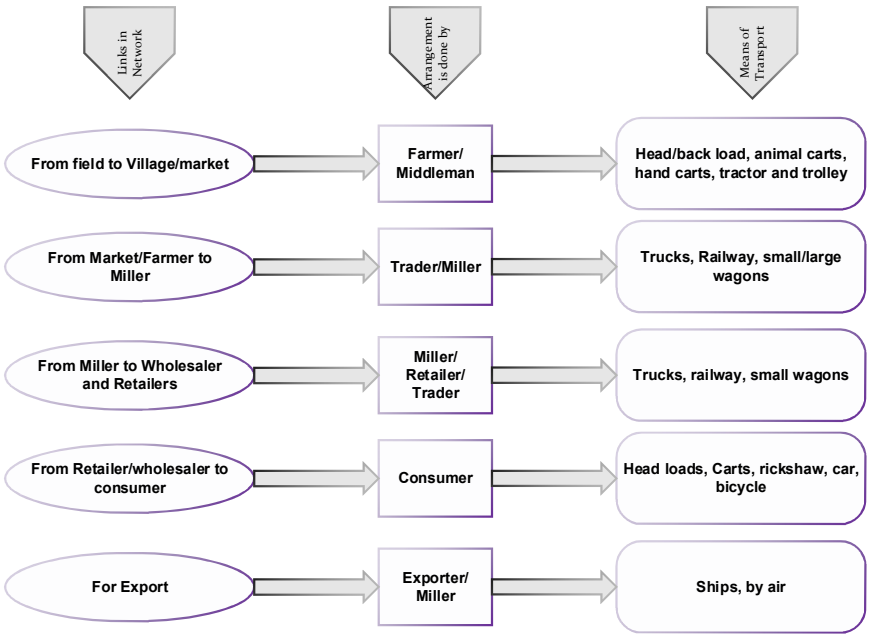
Production at the farmer's level involves plowing the fields, planting the seeds and cutting the crop. After the necessary equipment and seed procurement, farmers plough the fields. They regularly water the crops through extensive canal systems present in the region or through locally installed tube wells in the fields. When the crop is ready, harvesting is done either manually or using machinery. Small-scale farmers cut the crop by hand, stack it in small bundles and then manually load it in the thresher. This way they can save the straw which is later used for animal feed. Large-scale farmers use special machines which cuts and threshes at the same time.

Similarly, processors such as chicken feed processors source all of the necessary rice products from the mills or wholesale markets. They have sophisticated modern machinery to produce chicken feed. Once produced, they store it within the unit to finally supply to the market. Production is only done at the millers, farmers and processors levels. Other actors, such as wholesalers, retailers and commission agents, add value in this making process, through packaging, drying the crop or providing storage. During these different processes, actors share resources with each other and also use network level resources. This integration and sharing of resources provides a way for these supply network to survive disruptions.

5.2.2.4 Delivery

Delivery is one of the most important phases in these supply networks. There are two separate trends in the delivery of rice. One is at the paddy level, the other one is at the rice level. To make delivery efficient and effective, there are several processes involved, such as demand management, order management, warehouse management and transportation management.

Figure 5.5 Transport Vehicles Used at Different Levels of the Chain



Source: Developed by the Author

Once the crop is ready, then the farmers harvest it manually or with special equipment. Most of the farmers cannot store the crop once it is harvested, due to lack of storage sheds. They promote their product to the local market through middle man. Based on the quality, price is set. In the case of paddy, the price is set by the local market and mills. Similarly, by visiting the local market prior to harvesting, farmers are able to forecast their profits based on the market trends as well as last year's data. The next step is order management. Farmers have their own manual ledgers where they enter the orders. Various procedures are completed; for example, moisture is reduced according to customer demand. Packaging is done in two different bags; one is a polythene bag which is airtight. The second is a cloth bag where air can pass. They make sure that the packaging is clean and attractive, convenient to stack and easy to handle. Once the packaging is done, then it is either stocked by large-scale farmers who have the capacity, otherwise it is transported directly to the market or the mill. Farmers and middlemen

mainly use head loads, bullock carts or tractor trolleys to transport it to the local wholesale market (Figure 5.5).

Millers prefer to procure the paddy from the market, instead of from small-scale farmers because of the extra cost of logistics. Therefore once the paddy arrives at the markets, brokers deliver it to the mills. As explained earlier, brokers show samples to mill managers and take orders. Paddy price is mostly driven by the grain markets. Sacks are loaded into the trucks and wagons locally available near the markets. Loading is done by the market laborers on daily wages.

At the mill level, the order system is slightly different as now the paddy has been transformed into the final product. Most of the factories have their own specialized storage spaces where they store the newly developed product and deliver the old stock to wholesalers through large trucks. Small traders and commission agents arrange their own transport to take the rice from the mill. They also utilized the mill's storage space for minimal charges. Mills maintain all of the customers' data and their specifications of product quality and packaging. They also label the packaging according to customers' demands.

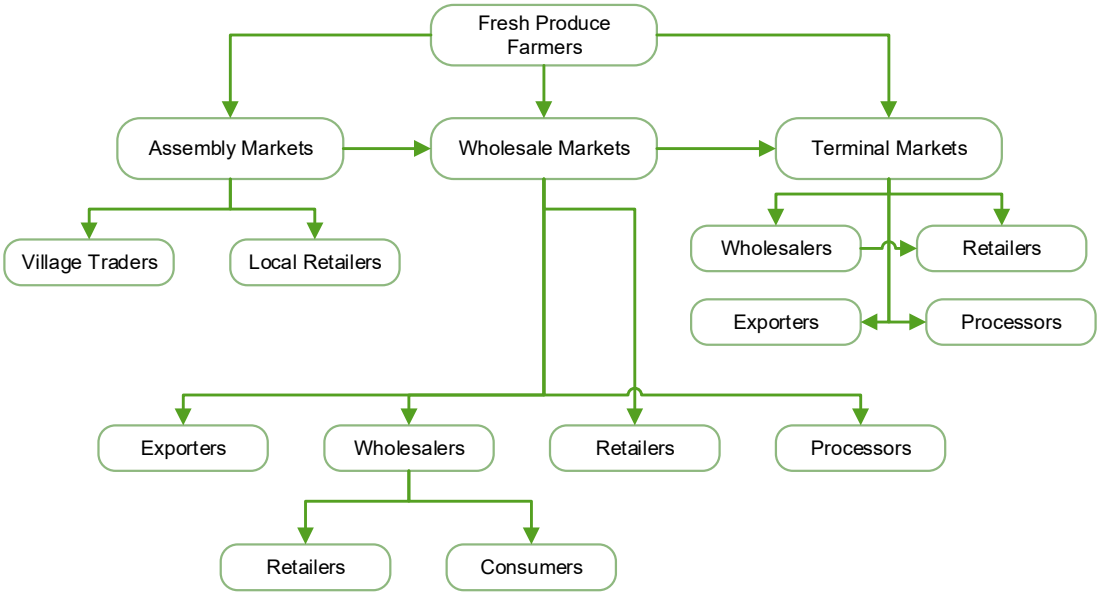
5.3 Fresh Produce Supply Chain – KPK Region (C1R2)

This region's climate and soil conditions are very conducive for vegetable and fruit production. Numerous fruit and vegetable varieties are produced in this region. However, due to under development and difficult hilly living conditions, production is a difficult task here. In certain high mountainous areas, vegetables are produced in the summer season, meaning these products are available throughout the year.

The network structure is similar to the Punjab region's fresh produce network. However, in this region, the size of the wholesale markets are much smaller and the distances between these markets are more stretched as compared to the Punjab region. There are mostly small terminal markets (small private wholesale markets) where traders and farmers negotiate purchases (Figure 5.6). Small retailers and consumers directly purchase the products from these markets. However, wholesale markets are present at district and big town levels. These wholesale markets have the same structure as the Punjab wholesale markets. There are only two big wholesale markets presents in the capital city of this province, which stock products from all over the province. These wholesale markets and terminal markets have commission

agents which invest in the farmers through traders and middlemen. Wholesalers are also allocated space in these markets. Many traders have their own good transport companies in these markets. Main actors in this supply network are farmers, commission agents, traders, middlemen, wholesalers and retailers.

Figure 5.6 Flow of Products in C1R2



Source: Developed by the Author

5.3.1 Supply Chain Main Actors

5.3.1.1 Wholesale Markets

Unlike the Punjab region, markets in the KPK region are not fully regulated. There are only two large scale wholesale markets in this province which are governed by the government regulations. These markets have their own market committee and commission agents are the main custodians of the shops. The largest market is found in Peshawar, the capital of the province. There are more than three hundred shops present in this market which are allocated to the commission agents. About two hundred small-dimension mini shops are also in the vicinity, which are rented to dealers. Small temporary sheds are also available in the market for retailers and wholesalers. There are no commercial banks in this market. This market is run by auction.

Other markets present in small cities and towns are not government regulated. These are private markets which have their own governing bodies consisting of groups of commission agents. Commission agents own these markets and rent space to interested parties. Every shop keeper is responsible for the maintenance and cleanliness of his/her respective place in the market. All local vegetables are traded here on an auction basis.

5.3.1.2 Farmers

Although there are few landlords, most of the farmers in this region have small landholdings in this area. Farmers have limited access to the latest information and most of them are uneducated. They depend on middlemen to access the wholesale markets. Irrigation systems in this region are self-developed; landlords/farmers use rain/glacier water on a system where each individual is allocated a particular number of days to irrigate. While most of the farmers sell their products to middlemen/contractors, a few have direct access to the market. Some of the large-scale farmers supply to the Punjab region wholesale markets as well.

5.3.1.3 Middlemen/Contractors

Most of the business is handled by middlemen and contractors in this region. These people belong to the farming families, who came into this business later, having good knowledge of all different types of produce. Commission agents invest in farmers through these middlemen and contractors. Middlemen focus mainly on vegetables, while contractors often work with fruit growers.

A middleman buys produce from the farmers and arranges transportation to the market (terminal or wholesale). Contractors buy the fruit while it is still on the tree thereby sharing the risk with the farmers. Although farmers earn less money, but in the case of disaster, the farmer's responsibility becomes minimized with this model. Besides, contractors have contacts throughout the country and can sell the products efficiently and effectively.

5.3.1.4 Wholesalers/Retailers

Wholesalers and retailers work in the same way as in the Punjab region's fresh produce supply chain. Wholesalers sit in the market (terminal or wholesale) and buy produce from commission agents at auction. They repack it and sometimes do the grading as well, before selling it to retailers.

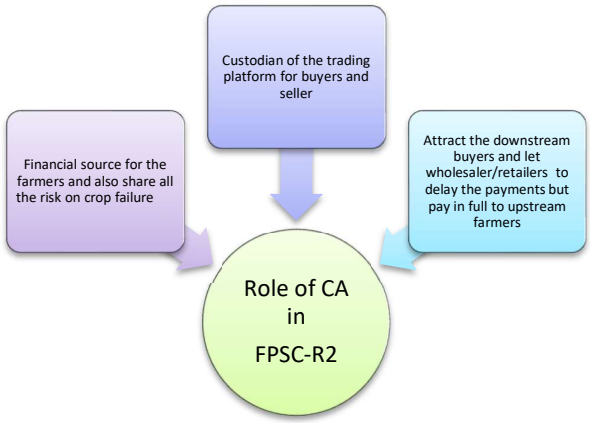
Unlike the Punjab region, this region has smaller retailers. Large-scale retail superstores are non-existent in this region. Retailers can be divided into three types; shopkeepers, pushcarts and small retailers who sit within the market to sell it to end consumers.

5.3.2 Supply Chain Main Processes

5.3.2.1 Planning

Major planning is done at the terminal markets, the main Peshawar market and at the farm level. At terminal markets (small, private markets spread all over the province), commission agents grant farmers loans Although there are banks in the province, farmers mostly depend on commission agents for agricultural loans. These loans are given through contractors and middlemen. These people evaluate different farmers based on their previous work, as well as their business reputation. Loan return procedures are also set in the planning phase. Sometimes farmers come to the market and deal directly with the commission agents. Commission agents also deal with different service providers, such as packaging material suppliers and transport agents. Storage cleansing is also done before produce arrives at the market. The summer season is the peak time for fresh produce, therefore most of the planning is done in winter.

Figure 5.7 Role of CA in C1R2



Source: Developed by the Author

Commission agents also maintain relationships with markets outside their immediate area. Although the majority of fresh produce comes from within the province, a large amount is also supplied to them from different parts of the country, such as the Sindh province. They book

their orders over the telephone and sometimes travel to these markets spread across the country.

Peshawar market is the largest market in the province and all of the planning is the same as for the Punjab markets. However, there are almost fifty commission agents who are of Afghanistan origin also working in the market. They finalize contracts with suppliers all over the province. These supplies are thus forwarded to Afghanistan. As Afghanistan is a landlocked country, it depends on Pakistan for most of its supplies. This market has better transportation, storage places and other infrastructure as compared to other terminal markets.

Similarly, farmers develop their contacts with the market through commission agents and middlemen. Some large-scale farmers also visit far-off markets so that they can directly supply produce to these commission agents instead of relying on middlemen. They also develop and maintain irrigation systems for their fields through collaboration with all of the farmers present in that area; they set a water quota for each farmer each season. Power law distribution can be seen in these networks as there are large numbers of farmers and other stakeholders in the network, however there are only two large-scale wholesale markets, which have a maximum number of connections. Retailers and wholesalers mostly prioritize demand requirements as they are directly linked to the end consumer. They also share this data with actors in the wholesale markets. As this province is highly vulnerable to natural disasters, information sharing is very critical during the response and recovery phase. Inventory planning is also part of their planning process. Inventory planning is based on the season and special occasions. Although there is no real advanced mechanism of demand forecasting, market trends and years of experience enable some form of planning.

5.3.2.2 Source

Sourcing includes processes such as obtaining, receiving, inspecting and holding the material before delivering it further downstream. Farmers mostly source fertilizers and other equipment from local markets. Most small-scale farmers are dependent on middlemen and commission agents who invest in these farmers by providing them with the resources needed to harvest their crops. Contractors often purchase the whole garden or crop before it is harvested. As they belong to farming families they have ample knowledge about crops. They also initiate vendor payments, with most payments made before crops are even ripe. On the

contrary, middlemen deal with the farmers once the vegetables are harvested. They inspect it by personally visiting the sites. They do the grading and packaging on the site.

Commission agents receive the products in the market, and complete their inspections there. Some of the produce is taken to temporary storage where it is stacked. These are special bunkers where light cannot enter, so that produce can stay there for a little longer. In all of the markets, commission agents deal with the labor on behalf of their clients, who unload the produce from trucks and trolleys. They take it to the storage room or auction floor.

Wholesalers obtain products from the commission agents at auction. They inspect and evaluate the source of the crop before participating in the auction. They take the products to their respective places in the market where they repack it. The labour union provides the labor to these wholesalers to transport the produce from auction floor to their place. Based on their relationships with commission agents, the price and quality of the goods, retailers buy products from different wholesalers. They use their own vehicles to transport stock.

5.3.2.3 Make

At the farmer level, farmers plough the fields and sow different crops. According to the irrigation turn, water is given to the crops. This area is mostly hilly, therefore farming technique are more difficult than compared to the Punjab region, however, the climate is suitable for growing vegetables and fruits. At all other nodes of this network, making processes mostly involve the packaging and grading of produce.

5.3.2.4 Deliver

At the level of farming, delivery is done in different ways. There are famers who deliver directly to the local market. They harvest the crop and make small bundles ready to transfer to local retailers and wholesalers. They hire vans or trolleys from nearby transport companies and deliver it to the market. Some of the farmers also sell it directly to the end consumer on the outskirt of their fields, on the roadside. They have laborers who carry the produce on their backs or use a donkey and cart. In the majority of cases, middlemen and contractors supply packed products to the markets. Some of the contractors have their own logistic companies and deliver goods to the market. Otherwise, they also hire vans from local transport companies. They also hire laborers to load and unload the products. There are also some

transport companies which go to different farmers early in the morning and pick bundles to take to the markets. This is seen in cases where middlemen or contractors are not involved.

At the wholesale market level, trucks have parking spaces near to the auction floor. Once the auction is finalized then the same truck is used to deliver to other markets or large-scale wholesalers. Produce may also be unloaded in the market and then after auction is delivered to the wholesaler using laborers who carry it on their backs or using small hand carts. As there are no big retail shops in the province, retailers normally bring their own vans which they hire from a transport company.

5.4 Staple Food Supply Chain – KPK Region (C2R2)

The staple food network in KPK region differs from the other three supply chains. This supply network is dependent upon other regions in the country for its supplies. In this region, only a small amount of rice is produced (called Begum Rice in the local language). This is small in size and is mostly utilized locally in the region. More than 90% of rice comes from Punjab and Sindh regions. Therefore, this network consists only of dealers, wholesalers, retailers, logistic providers and brokers. All major rice mills and production occurs in the Punjab and Sindh regions. Dealers/large-scale wholesalers buy rice from Punjab. They have their own storage places where they can hold stock to sell downstream to retailers and wholesalers. The role of these supply network actors are similar to the other networks discussed above.

In next section, the focus will be on analyzing the main supply chain business processes for main actors and these are discussed according to the categorization of the SCOR model.

5.4.1 Supply Chain Main Processes

5.4.1.1 Planning

Wholesalers are the major actors of these networks. They procure rice from the Punjab and Sindh regions and supply to all parts of the KPK province. Planning is an ongoing process; wholesalers develop relationships with brokers in the Punjab grain wholesale markets. These brokers come and visit markets in the KPK region and bring sample of their products. A courier system is also used to send samples. There are also local brokers who have built good business relationships with local rice dealers. They also have a good understanding of business in the Punjab region due to extensive travelling. They visit shops and negotiate the terms and

conditions of product delivery. Wholesalers also travel to the Punjab markets to inspect and build good relationships with the suppliers. As these wholesalers require financial backing, they must also find investors in the market during the planning phase. Investors are financially sound parties who offer money on credit and take their share from the profits. Wholesalers also deal with the local logistic providers and maintain storage spaces by rotating stock. Inventory management is done manually and within store, shifting and rotating is done by local laborers. They also take orders from retailers and schedule delivery dates and vehicles in this time. Downstream, retailers order for new stock based on their storage capacities and demand in the consumer market.

5.4.1.2 Source

Based on the samples, good will and previous transactions, wholesalers place orders. Orders are sent to them in trucks by third-party transport providers. Once the order reaches the wholesaler's premises it is offload by the hired laborers. As orders are placed by multiple wholesalers who divide the rent and share the labor force, an economy of scales is achieved. In other words, actors at same tier collaborate with each other to achieve an economy of scale. However, this inherent ability leads to a good collaborative response when disruptions or natural disasters threaten businesses. These actors have shared examples where they have come together to complete large quantities of orders given to them by relief agencies. This is very interesting finding in terms of resilience and will be discussed further in the following chapter.

Orders are packed into special airtight sacks. Each sack is inspected by the wholesalers. They have special equipment which they can use to draw out a small amount of rice from the sack to assess the quality.

Most of the small retailers come to the wholesaler's premises and inspect the quality of the rice before purchasing it. They bring their own vehicles or rent from a logistic provider. Large-scale retailers finalize orders over the phone and once it reaches their place, they inspect it and unload it. Retailers often repack the rice into smaller packs. Occasionally, wholesalers pack order according to the retailer's specifications.

5.4.1.3 Deliver

Once the product reaches the wholesaler's place, invoices are generated and payment is made via the bank. As the broker is arbiter between the suppliers and wholesalers, therefore this person is the guarantor of the payment. Delivery is sent on large trucks in special sacks.

Most of the wholesalers have mini-vans which are used to travel back and forth between the storage place and shops. From wholesaler to retailers, mini trucks are used to deliver. These trucks are hired from logistic companies close to the market. The sacks are covered with a special cover to protect them from rain. At the retailers place, local labor is hired to offload the sacks.

5.5 Summary

This chapter has described four supply chains in terms of their actors and major business processes. The first three supply chains have similar models, with some differences in actor roles. In a nutshell, these supply chains have wholesale markets where the majority of the goods are sold. Commission agents are the main actors in these markets. These commission agents drive these supply chains as they are informal financial sources for the farmers. They not only invest in the farmers but also, help them to recover from natural disasters. The reasons why the agents help their farmers/suppliers are discussed in greater detail in the following chapter. In the staple food supply chain (R1), millers are the main actors. They have a major influence on rest of the actors as their business processes are more advanced and they have greater financial reserves. The third supply chain has a similar model as the first one, however, in this case, the wholesale markets are mostly privately owned. They are more vulnerable to natural disasters because the government influence is minimum. However, they have a unique, well-established conflict resolution system, called Jirga, which will be discussed in the next chapter.

The fourth supply chain (the staple food supply chain in R2) differs from the other three. Commission agents have no role in this supply network. This supply chain also depends on supplies which come from other regions of the country. The reason is that all of the rice mills are located in the Punjab and Sindh provinces. The actors present in this network largely contribute to disaster relief processes by supplying products to relief providers. The following chapter discusses all of the relationships, capabilities, and vulnerabilities of these supply chains, as well as their contributions to supply chain resilience.

Chapter 6

Analysis: Findings and Discussions

The previous chapter has provided a rich description of each of the four case studies. Main actor roles were discussed and business practices were analyzed. In this chapter, individual case study findings are drawn together and a cross-case analysis is conducted. This chapter presents the main findings of this research.

It was postulated in the conceptual framework that the underlying activities of the four supply chain concepts of collaboration, knowledge management, logistics and sourcing are important in terms of supply chain resilience. The central aim of this study was to explore the underlying activities in each of these areas and to see whether they contribute, or not, toward the overarching concept of supply chain resilience. As mentioned in the methodology chapter, the data was first analyzed in relation to these four areas. Secondly, it was examined in relation to supply chain resilience elements (that is, agility, adaptability and alignment). In this way the study has explored how specific activities of collaboration, knowledge management, logistics and sourcing influence supply chain resilience capabilities.

The chapter is divided into four sections based on the areas identified in the conceptual framework: collaboration, knowledge management, logistics and sourcing. Each section presents the findings from all four supply chains, before comparisons are made, along with the relevant evidence. Each section also contains a discussion section where findings are compared with supply chain resilience literature to highlight the contribution of underlying activities to supply chain resilience. The chapter concludes with a discussion of two facilitating factors (network structure and social capital) in terms of supply chain resilience.

6.1 Collaboration

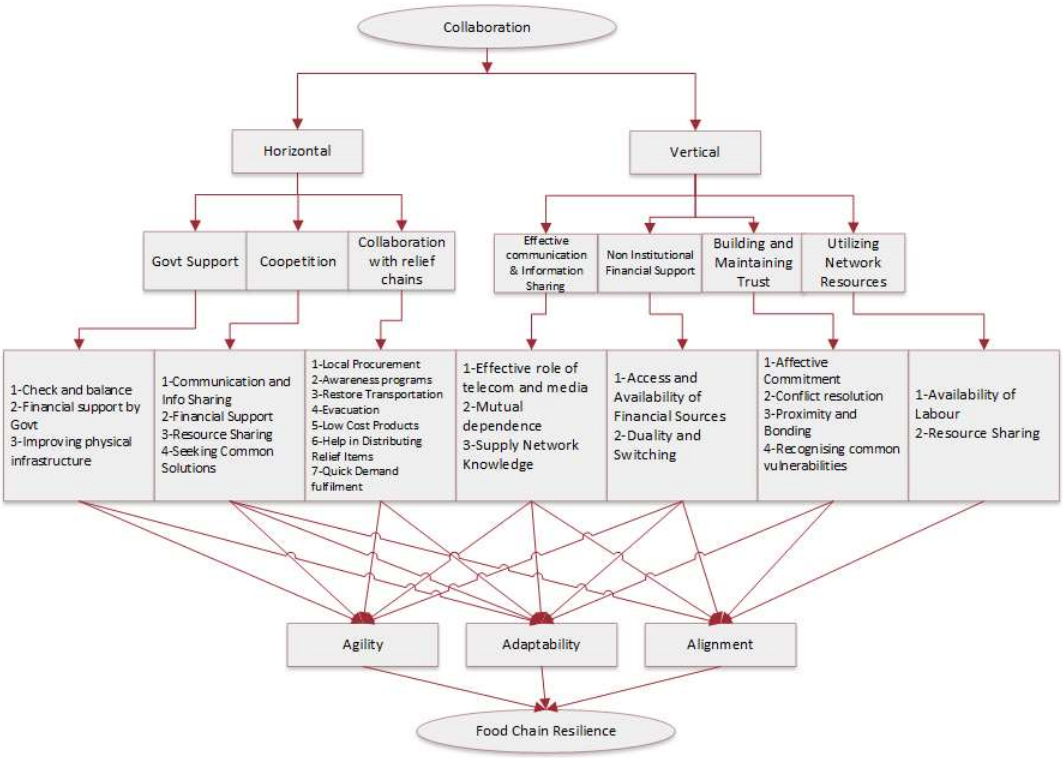
The literature argues that collaboration acts as a ‘glue’ that holds together different supply network nodes and helps to collectively deal with any disruptions arising from natural disasters (Chang-Richards, Vargo, & Seville, 2013; Christopher & Peck, 2004). In analyzing the data, this research has identified the underlying activities of collaboration that contribute to supply chain resilience. Indeed, this research has uncovered details of each element of

collaboration that not only enables resilience, but also supports other areas of the framework, that is, knowledge management, logistics and sourcing.

The results found that collaboration is active at both the vertical and horizontal levels within these networks. At a vertical level, buyers and suppliers collaborate, and at horizontal level there is clear collaboration within actors at the same tier (such as, different wholesalers in the same market working together), as well as with relief providers and the government. Collaboration is a key element for the overall system to survive and thrive in difficult times.

The next section outlines in detail the *vertical* collaboration activities that have emerged from the data, these being; effective communication and information sharing, building and maintaining trust, non-institutional financial support and utilizing network resources. The chapter later discusses those collaborative activities discovered at the *horizontal* level; in particular; coopetition, government support and collaboration with humanitarian relief chains. Figure 6.1 illustrates the details of vertical and horizontal collaborative activities and their relation to supply chain resilience.

Figure 6.1 Collaborative Activities Leading to Supply Chain Resilience



Source: Developed by the Author

6.1.1 Vertical Collaboration

6.1.1.1 Effective Communication and Information Sharing

The results found that effective communication and information sharing is very important to improve supply chain resilience. This not only increases visibility, but also helps to achieve flexibility, velocity and foster adaptability to new situations. This is particularly relevant to commercial operations of the supply chain and aids in building innate resilience to disasters.

6.1.1.1.1 Effective Role of Telecommunication and Media

In order to achieve resilience, supply chain partners need to consider the role of telecommunications, especially mobile phones and other media sources such as television. In the analysis, mobile phones were frequently mentioned as the best source of information and were often used for information sharing. Mobile phones provided greater accessibility throughout the region, as travel distances are long. Actors interviewed noted their dependence on mobile phones to deal with customers and suppliers. This helps them stay connected with each other during the response and recovery phases of a disaster. Part of the reason is that telecommunication providers are mostly multinational organizations and they have installed signal boosters at strategic locations with very resilient construction standards. This helps them survive natural disasters. This greater accessibility and coverage facilitates velocity (that is, speedy response in the supply chain). As one respondent mentioned, *"…our all work is done on phone, we have direct dealings with broker and factory as well. This is particularly helpful for us in difficult times when we cannot travel to other areas due to damaged infrastructure. At times we buy from broker and then we buy direct from factory as well... we ask them for samples... they send us... after looking at the thing we talk to him about the rates... then we get the stock... then we check the stock and if it matches with the sample we send him the payment in couple of days"* (WS3-C2R2). However, if there is no mobile coverage due to earthquake damage, these supply chain actors are forced to travel long distances and use alternative channels to acquire supplies or rely on buffer stocks. Mobile phone communication is more critical in Region 2 (R2). The travel distances here are much longer among different actors. Additionally, traveling conditions and the terrain are also difficult (for more natural disaster- related vulnerabilities see Appendix C).

Mobile phone communication also helps with accessing/sending information in real time. Timely information sharing is critical during the preparation and response phases of natural disasters, especially during floods. The government has built warning systems that can provide real time warnings concerning water levels in different areas. If one actor has this information, then they can share it with other actors in the network. Most of this communication is done through mobile phones. This communication is also used to plan ahead of the disaster, ensuring adequate stocks. Electronic and print media, such as television and newspapers, are also used to spread warning messages about known hazards, especially floods, throughout both regions. One good example of the use of mobile phones to prepare for an expected flood is as follows; *"When we get report then we try that we inform all our shopkeepers that so and so is the issue... what should we do now? they tell us we have stock... if they don't have then they say we are almost out of stock and hence you should load the stock at once... we send them at once... after few days flood comes"* (WS2-C2R2). These early warnings enable the alignment of processes between different partners in the supply chain. This fast sharing of information also helps quick speedy responses and the pre-positioning of inventory in advance of an event, and thus contributes towards achieving resilience. As earthquakes cannot be predicted, actors use other preparation strategies, such as holding buffer stocks or procuring goods from nearby proximal locations. The research data revealed that telecommunications and other media plays also play a critical part in achieving flexibility in these chains, as narrated in this example, "*We mostly connect with our buyers through mobile phone, it is easier, and it saves us lots of time and energy to travel to these areas. We develop the relationship and then be in contact through cell phones*" (WS2-C2R2). Another respondent in C1R1 stated that *"If there is severe shortage we get facilitation from internet that where there is availability of required things... like where we can avail in the world... wherever we got it... like we got it from Dubai we took, we got directly from Philippines, from India, wherever we get we took... in whatever quantity... we kept on taking it"* (CA1-C1R1). Not only is flexibility important, but timely communication and greater coverage also serve to allow speedy adaptations to new situations. These practices help supply chain actors continue supplying customers with goods in the response and recovery phases.

Mobile phone communications are prevalent in all four chains but are most effective in those areas vulnerable to floods. However, internet use is more prevalent in R1 than other areas, as this region is more advanced in its technology and infrastructure. As mentioned earlier, the

literacy rate is also higher than the average in this region. Here, media also plays an influential role in times of crisis. Although there are numerous shortcomings, particularly in terms of false reporting (where the media provides inaccurate reporting or screens propaganda against the local government), these actors depend on the media to obtain the latest information. The study has also revealed the positive effects of the media that helps end-consumers become aware of problems associated with floods and earthquakes, and essentially, more tolerant of price fluctuations and product shortages. As noted; *"Media is strong, so customers are aware, in case of flood if there is shortage or we have increased the price then customers knows that these are adverse*" (Rt1-C2R1). In short, the media (electronic, print and social), helps to align the interests and expectations of different supply chain actors and also contributes to these actors being able to better adapt to new situations.

Another interesting point respondents mentioned was that these channels help them to develop long-term relationships with each other. This, in turn, improves the collective understand each other's situations in difficult times. Effective communication and information sharing of real-time information has a significant effect on the performance of the commercial supply chains, as well as providing a degree of resilience that the data shows is critical during times of crisis to mitigate suffering and economic loss. In addition, it helps facilitate the development of long-term relationships and especially, mutual dependence.

6.1.1.1.2 Mutual Dependence

Mutual dependence is one of the core reasons these supply chain partners share information and communicate with each other in times of disruption. As most of the farmers do not have knowledge and access to wholesale markets, they are highly dependent on middlemen and commission agents who ensure that their products reach the final consumers. Farmers also generally have no formal sources of finance, thus they again turn to their respective commission agents for loans and financing. As such, whenever a farmer is in trouble due to a natural disaster or other social problems, as the commission agent's finances are also at stake. Hence, they work together to share information and take actions to mitigate any losses for both parties. Thus, it can be said that there is a high level of mutual dependence in these relationships. In this way, they provide concessions to each other. They also use barter transactions instead of money and deal in goods to replace cash. They also share missing information to reduce asymmetry. This dependency aligns the interest of the different actors involved and networks evolve naturally, in a way that they become dependent upon each

other. For example, one respondent stated, *"…however because of the trusted sustainable buyers and suppliers, also because of dependency on each other being part of same supply chain, their supplier and buyers shared the missing information with them*" (LP1-C1R2). This dependence also increases adaptive resilience in the aftermath of disasters; as another respondent commented, *"…[the] commission agent has invested in them, so the farmers are not in position they can pay back the debt so based on our recommendation, commission agent relax the payback time. Everyone waits for the next year and we trust our God that he will give us the prosperity next year*" (MM1-C1R1). In these relationships, commission agents always hold more power (due to their market position, greater resources and their financial investments). Any deals between farmers and commission agents typically favour the latter. However, the market committee present in these wholesale markets regulate the prices and ensure a degree of fairness for the farmers. There are many other economic and social problems associated with these supply chains, however these all fall outside the boundaries of this research. Rather, this research is only focused on exploring those activities that help these chains become resilient against natural disasters, and resilience here means to bounce back to the same/better situation post-disaster.

Mutual dependence has both negative and positive effects in normal business operations. While it reduces the flexibility of switching to different suppliers and potential buyers in the case of farmers, in difficult times it helps the network to respond and recover more quickly and effectively from natural disasters. Mutual dependence has been observed in C1R1, C1R2 and C2R1, as these chains are dominated by large hubs with multiple nodes attached to them, both upstream and downstream. In C2R2 where a large portion of the network consists of wholesalers with no hub firms, mutual dependence is minimal. Hence, they are more vulnerable to natural calamities. The analysis has also shown that in normal circumstances, where parties are not bound to each other, they are more efficient and had more flexibility, yet are highly vulnerable in difficult times and they take longer to recover. During times of disasters, the data showed that those nodes that were less mutually dependant are likely to suffer more or go out of business.

6.1.1.1.3 Supply Network Knowledge

In terms of supplier network knowledge, this research has found that having information about suppliers that extends beyond tier one, was very helpful for anticipating problems arising from natural disasters. At the hub level (the wholesale markets), commission agents

keep a keen eye on the financial strength of their suppliers. In many instances, they also have insights into the processes of their tier 2 suppliers as well. For example, one of the commission agent in C1R2 stated that, "…*we keep the information about our farmers through the help of middleman and also sometimes we know from where these farmers are getting seed and fertilizers, therefore we can ensure that our suppliers are up to our quality standards, and also in difficult time we are in better position to solve their problems*" (CA1-C1R2). Information such as this enables better preparation, particularly when financial or other support is needed for quick recovery after a disaster. As well as increasing visibility in the supply chain, information like this means that business do not rely on a single source. This ultimately increases supply chain flexibility.

Mostly these insights are gained through the site visits by the actors that are very common in all these networks. This study has observed a number of times when suppliers or buyers were visiting each other's places of work. While these visits may relate to other business matters, they also help to strengthen their overall relationships and provide more accurate information. Sometimes these insights are gathered through the middle man. This helps to increase visibility and alignment in the supply chain. For example, one informant told us that *"…although we sell most of the items to middle man, we know who are the buyers of that middleman. What are their requirements and what sort of customers they are serving*" (Fr1-C2R1).

Having this network wide view or knowledge is also important in terms of finding financial resources. Most of these supply chains depend almost exclusively on non-institutional financial support. In the case of C1R1, C1R2 and C1R2, this support is provided by commission agents, however in case of C2R2, dealers provide the required financial support to other actors. This support is an inherent character of these supply chains but becomes a key ability to respond and recover from the disasters.

6.1.1.2 Non Institutional Financial Support

One of the main vulnerabilities in both of the regions studied is the lack of formal financing options or financial institutions, such as second tier lenders that would typically be seen in a free market economy. Although there are multiple banks available, their high costs and complex products are significant barriers to engagement. Thus, local food network organizations (especially small-scale businesses) are reluctant to use their services. Although

the government undertakes many initiatives to effectively compensate for the damage done to these supply chains by natural disasters, people still prefer not to deal with these institutions. This issue is discussed in further detail later. Hence, the emergence of non-institutional financial support is a relatively unique feature of these case study supply chains and plays an important role in both of these regions. This financial support is a key feature of these chains that also helps facilitate alignment, flexibility, adaptability and velocity in these networks, and hence, are key building blocks for supply chain resilience. This feature is present in all four chains, but with different structures and actors. For example, in C1R1 and C1R2, commission agents provide this support, while in C2R1, it is investors and dealers who provide this support (however the support is minimal in this C2R2). The actors who do not have access to this support take longer to recover from disruptions associated with natural disasters. This also highlights the importance of the availability of this support in both regions. In cases where support is not available, family and friends come together to provide the necessary financial support to these actors, especially in the C2R2 region.

6.1.1.2.1 Access and Availability of Financial Sources

Many commission agents, in both R1 and R2, reported that they invest directly in the farmers. By investing in their key suppliers all parties become mutually dependent. This financial dependence is important when disaster strikes farmers. As one respondent noted, "…[w]*e give money to farmers and also arrange fertilizers or other raw material for him to help him grow the crops again, we also seek help from some of the investors and dealers, therefore also jointly invest on farmers and growers. We can sometime buy them tractor and give money for labour hiring as well*" (CA1-C1R2). This investment goes beyond contingency planning but is seen as a normal part of business operations that helps to secure regular supplies and improve quality. When floods or earthquakes strike and crops are destroyed, these same commission agents will again provide loans to these farmers so that they can recover quickly and maintain, as much as possible, a continuity of supply.

These efforts increase the speed of recovery, as other financial institutes are very slow to process transactions. These agents deduct loan installments as promised, however there is a great deal of flexibility in loan paybacks. As such, both parties become bound to each other. Flexibility in payback is important for the recovery of other supply chain actors after the disaster as well (especially the middlemen and farmers). For example, when asked how they deal with loan repayments if their suppliers face a natural calamity, one of the respondents

stated, "*They are totally relaxed, some say they will return next year and some put other conditions, but we negotiate and come to solution and give them maximum time*" (Pr1-C1R2). Although flexibility is there, they negotiate first and set up the terms. The negotiation is based on several factors, including the degree of mutual trust, and the magnitude of disruption. This is evident from one respondent's answer from C2R2 "…*when there was earthquake in our region, most of the shopkeepers over there around 70%... those who had made payment around 1 million rupees... they were ruined... we made compromise that build the shopkeeper... thank GOD there was not any my shopkeeper... they build their shops again and start earning on monthly basis... they took half a million loan and we asked how much loan you can return on monthly basis? They tell according to their capacity that I can give 10,000 or 20,000 rupees"* (WS3-C2R2). One purpose of these negotiations is to set the terms and conditions, but another big reason is to align the results of each party so that everyone can receive a benefit and to keep businesses running. However, there were many other instances observed where these negotiations were tilted in favor of the commission agents and farmers struggled to repay the loan. Respondents also recalled many other instances where farmers refused to return these loans. Indeed, in most of these cases, the transactions were based on mutual trust and needed for overall network resilience. More details on these issues are provided under the conflict resolution section.

Another revelation was that this alignment and mutual dependency enabled supply chain partners to quickly recover from disasters. This velocity (speed of recovery) is a fundamental ingredient of supply chain resilience. The access and availability of financial sources with such flexibility is only available in three out of four supply chains studied. The exception, case C2R2, is not based on a wholesale market system, and many respondents told us that while there were many investors available, due to continuous disasters (both manmade and natural), those investors have moved to other areas of the country. They have managed this non-availability of financial sources by reducing the batch size of orders and also by dealing on credit terms with their suppliers who are mostly from R1. This has reduced their profit margins and has made this supply chain considerably more vulnerable compared to the other three supply chains studied.

6.1.1.2.2 Role Shifting and Switching

The analysis has noted the characteristic of actors holding dual roles and of the interesting interactions that occur when switching between these roles in the supply network. This duality

comes from the fact that these actors keep themselves up-to-date about the market and they have good knowledge and understanding about how the whole system works. Numerous respondents have highlighted the dual nature of their roles, especially those who are located within the hub. Many times, these actors switch roles to support the important suppliers, for instance, an actor in C2R1 stated, "*…if he needs something like he asks to buy him 20 bags of fertilizer, I buy him that we do not charge him any interest rates we do not over charge him. Also, if he asks for some medicine we buy him medicine* [pesticide]*"* (CA1-C2R1). This activity help in providing linkages to their suppliers from the market and gave these suppliers the price advantage as they typically buy in bulk. Both these practices increase reliability and alignment within the supply chain. However, at other times, this switching of roles is merely done for just business purposes. As these actors conduct their business in the wholesale market where they have access to the knowledge and investment to do other businesses, they switch to other business for financial gains. Yet, whenever this switching is done for the sole purpose of providing relief support to their suppliers, it can help these supply chains actors to survive and recover from disasters.

Supplying the pesticides or fertilizers by the commission agent to the main suppliers (farmers) is not the only reason of this duality of roles. Indeed, this duality and switching also enables the actors to adapt to new situations more effectively. For example, as one of the commission agent mentioned, *"…[during] last flood we were having very poor business, so we started supplying the fertilizers, we also provide this fertilizer to our suppliers which are farmers in this case as well. It is because they don't have access or resources to buy that fertilizer, this fertilizer really helped us and we regularly started investing in it"* (CA1-C2R1). This not only helped the organization to survive difficult times, but other actors attached to this node also benefited from the new linkages and new investment. While this duality of roles is prevalent within wholesale markets, it was observed that the roles in the rest of the chain were more stable. Interestingly, there was no evidence of this feature in C2R2.

6.1.1.3 Utilizing Network Resources

Another important component of collaboration is utilizing network resources outside one's own control or ownership. This component has activities that are related to the sharing of resources and making the most of the available resources in the networks, especially in difficult times when the primary aim is to survive the disaster.

6.1.1.3.1 Availability of Labor

One key resource that is mentioned by the majority of the respondents is the availability of labor. At each wholesale market level, there are labor unions with a governing body who provide laborers to the commission agents, retailers and other actors who need it. These laborers are given training in handling, packaging, transporting, loading and unloading of the products and produce.

Similarly, at the farmer level, cheap labor is available to ensure the supply chain runs smoothly. For example, if a middleman has purchased crops from a farmer then that farmer also shares information about labor providers in the region. This information helps the middleman to easily access labor to take care of the crops (they are no longer the responsibility of the farmer). One of the respondents in C1R1 told us, "*We have the contact of local labor provider, 40 to 50 workers are present in every field, we give them salary on daily basis, These workers are local people who work in these fields. They stay there day and night, they take care of crops as well as cutting and plucking that is also done by them*" (Fr2-C1R1). The significance of these labor pools is even more evident in the following example where one of the respondents in R1 mentioned the labor issue present in R2; (some of the fresh produce also comes from the R2 to these R1 wholesale markets) "*Due to earthquake, many of the houses got damaged and we were in severe shortage of the labor which results in crop being over ripped and delivery was also delayed*" (WS2-C1R1). This example also demonstrates the practice of information sharing among partners. The researcher confirmed these labor issues when farmers were interviewed in R1. The farmers present in C1R2 helped their laborers who were working in their agricultural lands by giving them financial support and also using their links with government officials to help them access financial aid so that they could repair their houses.

While farm labor has a specific skill set, laborers within the hub are trained to handle multiple tasks. Flexibility is enhanced as during disasters if there is a shortage or need, then the labor can be utilized in some other tasks. Supply chain actors, such as commission agents and wholesalers, also support laborers financially by giving them short term loans on easy terms. Within the labor union, if there is less work, then work is divided in a way that everyone will benefit. This flexibility and fairness helps all actors return to normality after disruption.

Labor is easily available in all four supply chains and at each tier level as well. Part of the reason is poverty, lack of opportunity and low wages in both these regions. As a result, there were many incidents of exploitation. The researcher noted that many laborers were forced to work long hours and on barely minimum wages. Also, they were not provided with basic facilities and equipment for the physical demanding work. Even with these dreadful shortcoming, labor availability and flexibility plays an important role in supply chain resilience.

6.1.1.3.2 Resource Sharing

Other than labor, sharing logistics functions and activities is also prevalent in these supply networks. There were numerous instances recorded where one of the supply chain partners had arranged transportation on behalf of their buyer or supplier in the case of an emergency, *"…it is the duty of supplier to manage all the transportation, but in some emergency cases we send our own vehicle to collect the supplies"* (Tr-C2R1). This quick response by sharing resources helps achieve velocity in the network. Other than vehicles, storage facilities are also available near all of the hubs that are utilized by different actors. Mostly these facilities are privately owned by the key actors in the hubs. As the supply and demand is not clearly defined in these chains, for example, if there is excessive supply sent by the suppliers then these supplies can be stored in these storage facilities. Later, when there is demand for these goods, these items are brought to the wholesale markets for auction. The flexibility of these temporary storage facilities helps to regulate supply and demand. Resource sharing is mostly seen in the fruit and vegetable wholesale markets in both regions. It has also been observed that where actors are mutually dependent, resource sharing is far more common.

The motive for this resource sharing behavior goes beyond the economic. While in part profit incentivized, resource sharing is a deep expectation of the socio-cultural nature of both these regions. As mentioned earlier in the chapter outlining the research context, this country has a culture where people help each other and the sharing of resources is considered a norm. Indeed, while people do misuse or take advantage of each other, trust still plays an important role in these transactions.

6.1.1.4 Building and Maintaining Trust

The results have found that building and maintaining trust is a key element in the process of information sharing, financial support, combined logistic activities and all other collaboration related activities. The underlying activities involved in this component are affective

commitment, conflict resolution, proximity and bonding and recognizing common vulnerabilities.

6.1.1.4.1 Affective Commitment

It was found that a good working history and the length of a work relationship are fundamental elements that make supply chain partners emotionally committed to each other. It seems that mutual dependency is by far the largest contributor to effective collaboration among different actors. Yet, without a good working history no one becomes interested in investing in their suppliers or buyers. It appears that trust is derived from consistent and reliable actions and meeting expectations over time. It has also been observed on many other occasions, where actors are not mutually dependent on each other, that they will still conduct transactions as they were committed to each other. The society overall is very emotional in terms of dealing with each other. If two actors have a history of doing good business then they become socially bounded to each other. This affective commitment thus becomes a basic element of building trust within these supply chains. As one of the respondents in R1 stated *"...like you get a deal done and our partner fulfill commitment in a timely manner then trust and confidence is developed"* (CA1-C1R1). Further, one of the wholesaler defined trust as; *"…overall the attitude of the buyer matters the most, if there is an element of respect and no misbehaving, and also deal is done through proper negotiation, then trust is developed"* (WS2-C2R2).

This trust helps during difficult situations, and as noted earlier, natural disasters are very frequent in these regions. As all of these networks operate on a credit basis and joint investments are involved, developing and maintain trust is essential for these actors when circumstances change dramatically. They share information based on trust and long-term relationships. This commitment brings reliability and visibility in these networks. Reliability comes because they have good working history and actors can rely on each other in difficult times. Similarly, the length of relationship also increases visibility. As one of the respondents explained, *"…we do business with those with whom we are working since long... we trust them that they have worked with us earlier as well as we know their business"* (Tr2-C2R1). Actors who have visited each other's premises over a long period of time become familiar with each other's work and as a result, are more willing to collaborate.

Although affective commitment is important, conflicts still arise between actors in each tier and between tiers. Conflicts are typically related to financial transactions, the delivery of products, the (poor) quality of products and other transactional matters that often happen between trading parties. During disruptions, lead times also increase, the quality of products are also compromised and similarly financial losses by some parties lead to many conflicts. Fortunately, these supply chains have a special conflict resolution mechanism that helps resolve problems and restore trust among actors.

6.1.1.4.2 Conflict Resolution

A significant finding of this research is the nature of the conflict resolution mechanisms present in these supply networks, especially in Region 2 (R2). Effective conflict resolution increases the trust between all supply chain actors, as they know that if something goes wrong, then any resulting conflicts will be resolved through this special system. In C1R2 and C2R2, conflict resolution is the responsibility of a local committee called 'Jirga' in the local language. A Jirga is formed when there are serious disagreements, such as payment delays, property disputes or any other issue that cannot be resolved by the parties directly. This is equally helpful in disasters when there are serious disruptions over supplies or finances. For example, one of the market committee members in C1R2 stated, "[the] *farmer has lost everything and dealer has their investment in that farmer through the commission agent. Because of the delay from farmer, there is conflict among all parties then we announce Jirga, market committee member such as vice president, general secretary, chairman, deputy general secretary is part of that Jirga. All the supply chain partners who are part of that conflict also attend the Jirga, we take undertaking from all parties involved that whatever Jirga will decide will be acceptable by everyone*" (MC1-C1R2).

A Jirga is a standing committee whose members are mostly reputable elder members of the society who are acceptable to both parties in dispute. This research has found that market committee members, farmer representatives, reputable elderly commission agents or other notable persons in that market can become part of the Jirga. This alternative conflict resolution system has helped local government and other law enforcing bodies by resolving hundreds of disputes. Indeed, the formal system of justice is already overburdened and slow, which makes this alterative system even more important for these parties. Many of the respondents mentioned that the formal judiciary system in the region is slow and expensive, therefore they prefer to resolve their disputes via the Jirga.

The Jirga has a simple process that it follows. Both parties or groups appear in front of the panel and present their cases. They are given adequate time and witnesses from both sides are questioned. In serious cases, both parties swear an oath (holding their hand on a religious book). The decision is made based on the majority opinion. Their prior experience and understanding of the local system guides them in their final decision. Jirga panel members require the consent of both parties involved before announcing a decision. This process of taking consent is called 'Waak' in the local language and refers to the process where parties give the power of attorney to these Jirga members. This process provides a legal aspect to these decisions as well. Usually, the panel takes 1 to 2 days to reach a final decision, but it can take up to a few weeks. Both parties must accept the final decision. If one party violates the decision, social boycott or fines are imposed on that party. In most of the cases, people accept the decision. In cases where the parties do not accept the verdict, they can take the matter to the formal judicial system. If the loss happened due to a natural disaster, then this loss is typically shared among the parties, as determined by the Jirga. This risk sharing phenomenon helps achieve flexibility and further aligns the interest of supply chain partners.

As the market committee is also involved in the Jirga, it has government support as well. Also, in R2, the provincial government has given legal status this Jirga system by forming the Dispute Resolution Councils in 2014. Many local reputed persons (doctors, social workers, education professionals and retired civil/military officers) are appointed as neutral mediators to resolve disputes among different individuals. Interestingly, the local police force frequently recommends that commercial issues should be resolved through the Jirga system in the first instance. This conflict resolution process also helps individuals adapt to new situations in the aftermath of a disaster. As one respondent stated, *"Jirga is also called when farmer delays the payment and we compromise with the dealers, we ask both of them and we take undertaking that whatever Jirga will decide will be acceptable by both of you*" (WS1-C2R2).

In R1, there is no such Jirga system and the government has made no effort towards establishing such an institute. Most conflicts are resolved by the parties involved themselves. Occasionally, the market committee is also involved in solving issues. However, in most cases, the matters are reported to police and other formal legal institutes. This study found that wherever matters are reported to the Jirga, they were resolved quickly and members were able to respond to disruptions quickly, when compared to other disputes that went through the region's legal system.

6.1.1.4.3 Proximity and Bonding

Another important underlying component of trust building is proximity and bonding. A generally held view is that suppliers who are in close proximity and actors who know each other well and live in the same area, are considered to be more trustworthy. Another reason for this trust is the social capital that is built between these actors. Typically, actors who are in close proximity have stronger bonds than others, an issue discussed further below.

Living in the same area or geographic proximity increases visibility, as it is easier to visit each other. It also enhances the velocity of the supply chain. Velocity (in terms of lead-time) improves, as transportation takes much less time. Suppliers located in close proximity are the first ones to bring their products to the market. As one of the commission agents stated, *"…local farmers who are close to the market bring their stuff as they don't get affected by the floods that much"* (CA2-C1R2). Additionally, if supply chain partners are closely knitted together through friends and family circles, then increased levels of trust are observed. As one of respondents mentioned, *"…trust is that we know your house is at so and so place, and they are doing good business, their crop is good, we have good relation with them... it is a kind of trust..."* (LS1-C2R1). This trust element helps in achieving visibility at the process level, where buyers in the wholesale market can evaluate the quality of the farming processes at the farmer's level.

Conversely, this geographic proximity is missing in the C2R2 case. Actors in this chain procure their rice from suppliers in R1 and there are long travelling distances between these two regions. This chain is often affected by disruptions caused by floods and earthquakes, and when physical infrastructure, like bridges are damaged, then lead-times greatly increase. These actors keep buffer stocks to respond to such situations, and as floods are generally more predictable, they also order ahead of time. This also provides them time and an inventory cushion to deal with disruptions. One of the interesting elements within this trust component is that many of these actors explicitly recognize their vulnerabilities. They understand the situation of other supply chain actors in their network as they also face similar problems. This recognition also hints at shared empathy and enhances the amount of trust between them.

6.1.1.4.4 Recognising Common Vulnerabilities

One of the reasons for trust in these chains is that actors recognize common vulnerabilities that arise from natural disasters. This not only leads to the alignment of these actors' interests,

but also increases flexibility in the supply chain, that is also important for resilience. Two of the most critical vulnerabilities reported were, delayed deliveries and quality issues in these chains (see Appendix C). As one of the respondents noted, *"Because of flood, our supplier couldn't deliver on time, he called us and told that there will be delay so we support the supplier by not putting penalties because he had a genuine issue... he has informed before time... so his financial loss is covered by this way"* (Rt1-C1R1). Similarly, another one stated that, *"We pose some financial penalties on our suppliers if they fail to deliver on time or if there is some issue with the quality. But, in case of natural disaster, we are very much flexible"* (Rt2-C1R1). However, this aspect of flexibility and alignment is not common in these networks, but this is a significant finding that can be used to build trust among supply chain partners where they will be in much better position to cope with natural disasters.

6.1.2 Horizontal Collaboration

Collaboration among suppliers and buyers is important to prepare, respond and recover from natural disasters. Equally important is collaboration among horizontal actors of the same tier within these supply networks. These actors are in an ideal position to help each other in times of crisis. This research has found that in times of crisis, supply chain actors at the horizontal level do indeed collaborate with their competitors, government departments and other relief providing organizations. This analysis has divided horizontal collaboration into three main categories; coopetition, collaboration with relief providers and collaboration with government.

6.1.2.1 Coopetition

The results have found that actors at a same level within the hubs not only compete, but also cooperate with each other especially in times of disruptions. There were many occasions where actors at each tier of the network cooperated with each other to deal with natural disasters; these were farmers, middlemen, wholesalers and sometimes retailers. Other than same level coopetition, the research also highlighted an example where one buyer actively managed and created the cooperative ties within its suppliers who had no competitive tension or ties. This analysis has postulated that there are five sub-dimensions or activities that constitute coopetition. These are; communication and information sharing, financial support, resource sharing and seeking common solutions. Further discussion on whether these

activities are contextual and/or are supported by literature is included in the discussion section on collaboration.

6.1.2.1.1 Communication and Information Sharing

The data shows that information sharing and regular communication with competitors is very common in these supply chains. For example, one commission agent stated that, "…*we regularly communicate with other commission agents* [competitors] *and share information such as which crop is going good, about suppliers and if we have information about disaster then we also tell other people in market"* (CA1-C1R1). This information sharing helps align the interests of these competitors. Such disaster related information helps these actors to plan ahead or cope with disruptions arising from these disasters. These interactions mostly happen at auction-based wholesale markets (C1R1, C2R1, C1R2), where commission agents are co-located. Mills owners are connected with each other through different associations where they share information. Similarly, in C2R2, wholesalers in the grain market interact with each other in order to find common solutions. All of these are examples of horizontal coopetition. Motives for these behaviors include mutual interest and empathy in the face of frequent disruptions.

Similarly, farmers in the same village who ostensibly compete with each other also communicate and share information. One of the farmers discussed how he advised his fellow farmer concerning new farming techniques, "*I say to him that your crops needs fertilizer, so you must use so and so fertilizer... it has this time then why are you getting time over... your crop is getting so and so disease so use that spray…*" (Fr2-C2R1). There was another respondent in C2R1 who stated that they arrange special training for farmers where they invite all of their suppliers to provide training. This platform gives those farmers the opportunity to learn best practices, thus raising the standards of crops that can better withstand natural calamities. Based on these interactions, it can be said that during difficult times, these actors come together and help each other to respond and recover quickly from the disruptions.

Retailers also bring competing suppliers together through training programs. These suppliers then started sharing useful information with each other to improve the quality of products. This alignment of interest among peers becomes even more important when there is a

disaster and they have to work together. These actors support each other financially and also share resources during difficult times.

6.1.2.1.2 Financial Support

Another phenomenon observed in these coopetitive relationships is the financial support of different actors at the horizontal level. Most of time the reason of this support is reciprocity or the fact that these actors are co-located at the same hub or area.

It has been observed that if one firm has a shortage or excess of supplies, then it often coordinates with other firms present in the wholesale market to deal with the situation, for example; *"…now here the system is that as soon as farmer gives vegetable to commission agent... another commission agent invests with him... for instance you have 10 trucks… you say to another commission agent I have 10 trucks if you want to invest then you can take 3 trucks from me*" (GR1-C1R1). This flexibility is an important ingredient of supply chain resilience and helps to compensate for fluctuations of inventory throughout the market.

This cooperation with competitors also enables adaptability within these networks. Post-disaster and especially in the recovery phase most actors face many financial issues. Due to limited accessibility of bank loans, actors in the same hub often help each other by giving interest-free loans with flexibility of return. As one respondent explained *"…in difficult times, when our competitors have financial issues then we help them financially like loans so that they can invest on their suppliers or buy stuff from farmers, similarly if we are in trouble then they help us"* (CA3-C1R2). This trend has been observed in all three chains where a hub is present (C1R1, C2R1 and C1R2). Although there are no hub firms in C2R2, organizations present in the same geographic area still assisted their peers in difficult times.

This cooperative behavior among the firms at the same level also contributes to velocity, or the speed of recovery to normalcy after disruptions. Several respondents in R2 stated that after an earthquake, they all work together to help anyone who has suffered significant physical damage to their assets, for example, *"*[the] *shop was destroyed in earthquake of our neighbour, we helped him by collecting money from everyone so that he can build his shop again"* (CA1-C1R2). Although, this other actor who faced significant financial problems was part of the hub, his/her presence (or absence) would not affect the overall functionality of the network. Even so, actors supported their competitor. This relationship among competitors strengthens these hubs against external threats.

6.1.2.1.3 Resource Sharing

In addition to financial support, resource sharing among actors at the same tier also contributes to some of the components of supply chain resilience. Results have found that having a common supplier, or sharing of logistic resources amongst competitors, is prevalent in these supply networks. This sharing of resources aligns the processes of firms involved and enables supply chain resilience.

Again, this mostly happens at the hub level. An interesting example was found where twenty actors at the same level have all invested in a common resource. For example, one of the commission agents commented; *"they have a shop and there are 20 middle men at our shop... those 20 middle men hire an accountant... we have our own accountants who serve us... but they trust little on them and hire their own representative as well"* (CA2-C1R1). Although the reason was not related to any disaster, this level of sharing among actors helps them cope with disruptions in the supply network.

There were other occurrences where competitors shared transport and storage spaces with each other. As one farmer stated, "*we all farmers have dealing with same transport company which picks up the product from our places, we put the products packed in special packaging alongside the roads and this van will pick it up from there"* (Fr2-C1R2). Having these common resources encourages actors to keep common packaging standards on one hand, and on other hand they also achieve economy of scale through this process. However, there were only few farmers who work together to negotiate deals with logistics providers, nevertheless, they have better packaging standards and also help one-another in other related business matters. Yet, mostly it has been seen that they all deal individually with logistic providers and that logistic providers would be in more control in those cases. It can be said here that if farmers work together to negotiate with transport or storage companies, they can deal with disruptions in a more effective way.

6.1.2.1.4 Seeking Common Solutions

In addition to these episodes of resource sharing or financial support, these competitors also seek common solutions to disruptions arising from natural disasters. In many places in R2, data has shown joint investment in irrigation systems, amongst actors who are otherwise competitors. Previously, there was no mechanism to store water. These farmers use natural water and have made special irrigation systems to irrigate their crops. As one farmer

explained, "*there is Swat river... you will see... we all people have 2 to 3 channels for us… government did not… we did on our own and from the same every person irrigates land according to one's personal needs..."* (Fr1-C1R2). These channels were destroyed in the recent earthquake but were rebuilt using money and resources contributed by most of the local farmers. This alignment of interest makes farmers more resilient against these disasters as they derived their own solutions more quickly compared to others by emphasising collaboration with the competitors. A similar process was seen after the recent floods that covered the marketplace with deep mud. As this market is a hub entity, it is crucial to the overall supply chain network in R2. As there was hardly any government support or relief provided, the market actors together invested to deal with the situation. As this commission agent recalled, *"…large amounts of mud in last flood which came with water was huge problem and we have spent a lot of money on clearing that mud, we all come together and contributed and hired a company to get rid of that mud. We also used our own labour to clear out the water and mud"* (CA1-C1R2). This example highlights the adaptive capabilities of these supply chain actors to new situations.

In the above example, many problems were highlighted by the respondents. All of the records, that were paper based, were totally destroyed by this flood. This could have presented an opportunity to take advantage of this situation and avoid debt, however the trust element saved them, as their buyers and suppliers helped to re-establish accurate records. There were other problems with poor infrastructure and building compliance that is a significant vulnerability within these networks. However, during visits to the markets, the researcher observed that they are now building new shops according to the standards. On occasion, these competitors also come together and become the pressure group against the government, as one farmer explained, *"at times if we feel more fear from river, then we request government that they build safety wall alongside the rivers for us... there have been few safety walls been built... they offer protection..."* (Fr2-C1R2).

Overall, coopetition was observed in all four supply chain networks. It has been argued that coopetition helps improve the velocity, flexibility and alignment of these networks. Nevertheless, there is lack of uniformity in these interactions. Most of the time, these are just informal interactions initiated out of mutual self-interest and facilitated due to the close knitted culture of these regions. Yet, wherever these competitors have collaborated, the data

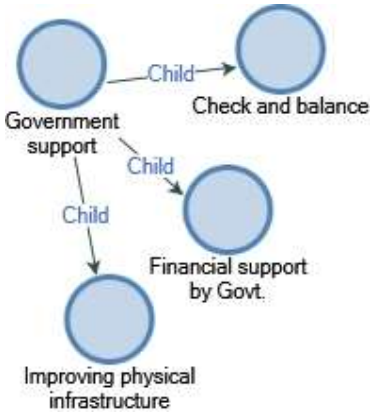
shows that they have responded and recovered from natural disaster more efficiently and effectively than other actors.

6.1.2.2 Government Support

The largest contributing factor towards resilience in the horizontal collaboration category is government support (GS), especially from provincial and local governments. It is seen that GS facilitates reliability, velocity and adaptability in these supply networks. It has been found that R1 has more GS for these supply networks than R2. The basic reason is that the local and provincial governments in R1 are more financially stable than the R2 government. There are many vulnerabilities and challenges associated with the government's role in these networks (see Appendix C). A lack of formal financing options, political problems, network related problems (lack of consistency in supply and demand, speculation, price fluctuations), and many physical vulnerabilities (such as poor infrastructure), are some of the examples that show poor planning and disassociation among different actors of these networks. These challenges are present in both of the regions. Nevertheless, this research suggests that GS is still the largest contributing factor to resilience despite its shortcomings.

The analysis has found that there are three main activities in GS which help achieve supply chain resilience. These are check and balance, financial support by the government and improving physical infrastructure.

Figure 6.2 Different Components of Government Support



Source: Developed by the Author

6.1.2.2.1 Checks and Balance

The data indicates that the checks and balances provided by local and provincial governments are very important for improving resilience in these supply chains. One of the main factors is

to normalize the demand and supply in these chains. As previously mentioned, market committees and government bodies help to regulate the functionalities of these networks. During natural disasters, local governments make sure that no one is hoarding produce in order to create artificial shortages in the market. Compliance is enforced through inspection teams visiting market storage places and warehouses in the area. This ensures reliability in these chains through the continuous supply of products to the wholesale market. The government not only ensures that there is no hoarding, they also impose limits on the amounts which can be purchased by each actor involved in the market to enable consistency in these chains. These measures also align the interest of the whole market. As one government representative in R1 noted, *"…being member of market committee we make sure that demand and supply are consistent in the market and there is no artificial shortage, we do surveys and have inspection teams who go to each godowns to make sure there is no extra storage of products, if there is deliberate shortage created by some party we impose heavy penalties on them"* (GR1-C1R1).

Local government representatives in both the regions also revealed that if a natural disaster destroys crops and there is a need for supplies, then the government will import products from other countries to complement these supply networks and support relief efforts. For example, "…*in those situations government sits and tries to find out a solution... then we get some of the things in the form of aid and also we import things from abroad"* (GR1-C1R2). These practices help the overall functionality and velocity of these supply chains and ensure they are able to return to normal operations as quickly as possible.

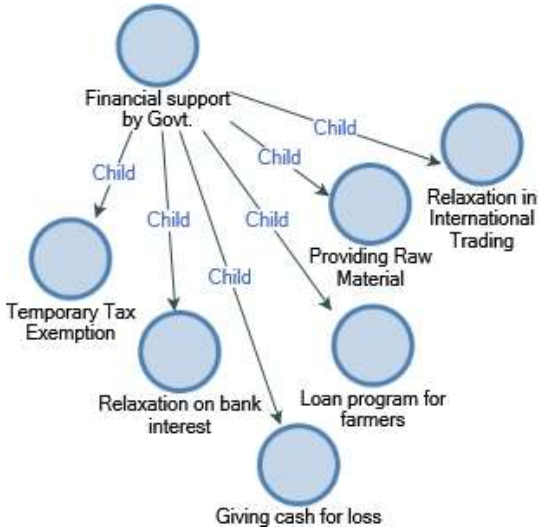
One of the interesting discoveries was the alternative channels that are provided by the government for these networks, called 'Sunday markets.' These are special markets operated by the local governments. Products that are mostly of low quality are sold to end customers here. While, these markets are not designed for any specific disasters related reasons, they play an important role in times of disruption. For example, during natural disaster-related disruptions, the products that are of poor quality go to these small markets directly from the hub. These markets are even more important for the fresh produce in both regions studied because of the perishability of the products, and the limited storage spaces available to store them. These low-quality products are cheap and typically have high demand in these small markets and can be viewed as a relief item to the population in times of disruptions. As the commission agents have already invested large amounts in the farmers and with these low-

quality products, they face large financial losses. Yet having this flexibility of different channels helps them to cover some of the losses incurred by these natural disasters and contributes to the survival of different actors present in the network.

6.1.2.2.2 Financial Support

An equally important finding is the financial support provided by the government to these supply networks. This support is provided in a variety of ways, however financial support is focused mainly on farmers. One of the respondents reported that, *"*[the] *Government announces special packages for farmers after major disaster it can be in form of cash and there are also loan programs from bank, this helps the farmers to spring back quickly"* (CA3-C1R2). This financial support enables a better response and a quicker return to equilibrium, thus enhancing the velocity (speed of recovery) of supply chain. The components of this financial support are noted in Figure 6.3 below.

Figure 6.3 Elements of Financial Support by the Government



Source: Developed by the Author

There are many other forms of support that are provided to these networks at different levels by the government, such as a relaxation of bank interest, cash distribution, temporary tax exemptions, loan programs for farmers and the provision of raw materials. All these measures help these actors to adapt to new situations that arise from disruptions. Nevertheless, while this centralised government support provides relief to these networks, it is the non-institutional financial support that remains the largest form of assistance for these chains.

6.1.2.2.3 Improving Physical Infrastructure

The role of government support in maintaining and improving physical infrastructure is also crucial in achieving velocity and reliability in these supply networks in both regions. In particular, this analysis highlights the need for creating safety walls/stop banks alongside the Swat river as one of the fundamental responsibilities of the government to protect the crops and cities from floods. Often these safety walls are actually built, but because of corruption, the material used in these walls is not of good quality. Failure is all too frequent and ultimately results in crop loses. One respondent lamented, "*there was so much rain and flood… safety walls were broken... there are corrupt people... banks are made up of soil and not cement... every year the rains demolish it... they say it broke from here... this happen and that happened... we keep on waiting"* (Fr1-C1R2). But there are other instances where respondents were positive about these safety walls. Hence, if elements of corruption could be minimized, then even more resilience could be achieved against these floods.

Respondents identified a number of other elements that would help to protect their businesses, including draining flood water, reinstating bridges, road construction and an efficient canal system. Building reliability into the physical infrastructure is important, both for the preparation phase and for ensuring continuity of supplies during the response phase. This is evident in the following example, "…*if the road is ruined... like when there was flood in this region... this time when I went I saw very nice bridges have been built... they have worked a lot... but they can't work to this extent during emergency... they have to look after people and can't do construction, therefore they need to do this work before the disaster strikes"* (WS2-C2R2).

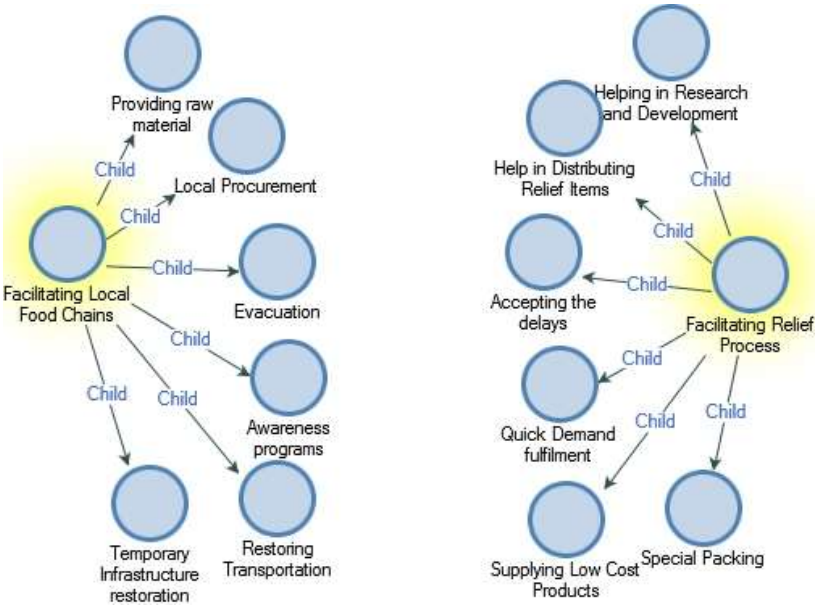
Overall, the focus of GS is ensuring that these food supply chains receive the support they need to continue operations before, during and after the disruptions. Doing so helps mitigate the need for food relief chains and the suffering of the population. GS helps these chains to achieve velocity and builds reliability into the system. It also contributes towards the adaptability of these actors in the aftermath of disasters. GS is more evident in R1 where the local and provincial government is more stable, and the frequency of large disasters is relatively low. On the other hand, in R2 there are already many relief supply chains that provide relief to the communities affected by natural and man-made disasters. Therefore, in

R2, the interaction between commercial food supply networks and relief providers is an important phenomenon that contributes to the overall resilience of these food supply chains and the community as well.

6.1.2.3 Collaboration with Relief Chains

In disaster-prone areas, especially in R2 of this study, both commercial and relief supply chains work side-by-side. Therefore, the interaction between both these chains is crucial for an effective response to disruptions. However, the roles of each supply chain are bit fuzzy in these areas, and while this study has investigated the possible collaboration between these chains, it does so from only the commercial chain's perspective. Nevertheless, the data shows that interaction between these chains (commercial and relief) can be broadly divided into two categories. The first category is where relief providers facilitate the usual operations of local food chains, while the second refers to those instances where local chains facilitate the relief processes. Clearly there is a cross-over in roles between commercial and relief, but the data shows that each will move into the other's role when a vacuum exists, or a need is evident rather than in direct competition. However, not all respondents were happy with the role that the overflow of relief supplies has on prices and the overall market. Either way, the interaction between these two chains plays an important role in enabling overall food network resilience, especially so in R2. The main roles and functions performed by the local food chains and the relief food chains are noted below in Figure 6.4.

Figure 6.4 Main Elements Contributing to Inter-Chain Collaboration (Commercial/Relief)



Source: Developed by the Author

6.1.2.3.1 Facilitating Local Food Chains

Most of the time, general government support is not enough to deal with the impact of large disasters. Therefore, a significant number of relief organizations work in these regions. Both NGOs and public/governmental relief organisations, such as the NDMA and the Army, support relief efforts. These private and public relief providing organizations have their own specialized networks, agendas and terms of references for their work in these regions, however their wider operations were outside the scope of this research. This study was specifically interested in how local supply chains interact and collaborate with these relief chains, as relief organizations are also part of the food networks under investigation, and food is the largest relief item provided by these agencies.

There are number of activities that were revealed in the analysis that facilitate local food chains such as; awareness programs, evacuations, the supply of raw materials, restoration of transport and infrastructures, and local procurement by relief chains. This later activity is particular important, as it not only helps the local chains, but also helps the economy of the region to function in difficult times. Local procurement by relief chains takes various forms; sometimes it is on-the-spot purchasing of food products from local chains, while at other times there are formal contracts with different actors to procure food items. This was highlighted by the following actor, *"…when there was an earthquake than National disaster management and other agencies prefer to procure food items locally, because bringing food from other areas or countries is time consuming, we have helped many agencies to get local food from our market"* (MC1-C1R2). This local procurement is important for the food networks as it provides much-needed cash flow and an outlet for food that can no longer be delivered to regular customers due to disruptions. Local procurement by relief providers not only helps feed affected communities, it is an important source of revenue and maintains the velocity of perishable food items.

In both R1 and R2, there are other relief providing organizations that provide raw materials to these food chains, mostly to the farmers. As farmers are the ones that are usually impacted the worst, this support enables them to better adapt to the new situation. This adaptability is one of the building blocks of supply chain resilience. As one actor stated, *"...in the recovery phase, when farmers are in great trouble because of limited resources then international relief providing companies provide them seeds and fertilizers which help them adapt to the new*

situation" (CA3-C1R2). With financial support from the government and material support from relief providers, these supply chains can more quickly return to normal operations.

Velocity is another important component of supply chain resilience that is greatly impaired due to damaged infrastructure and transportation networks. Hence, relief providing organizations facilitate the restoration of damaged transport and infrastructure networks. One respondent noted their experience, "*When the bridge was destroyed then they unload the products in small trucks and then in small boats to reach to the other side of the bridge. Those boats belong to the Army. The Army also makes the temporary bridges there"* (LP1-C1R2). Clearly, these temporary solutions and the longer-term transport infrastructure development has a large impact on the velocity of the operations of both relief, and local, supply networks.

6.1.2.3.2 Facilitating Relief Processes

The second part of interaction with relief chains is where local food chains facilitate the relief process. One of the major components of this process is quick demand fulfilment. The demand of relief products by the Army, NGO's, international relief providers and local relief providers increases many folds before the flood season or during the response phase of any natural disaster. As most of these companies/NGOs procure these items from local food chains, the capacity and responsiveness in terms of demand fulfilment of these chains becomes important.

In R1, it is mostly the retailers who are involved in fulfilling this demand, whereas in R2, it is the wholesalers who provide the goods. Regardless of who the suppliers are, they are usually well-prepared to respond the situation. The data reveals that having additional backup human resources (labor), multiple suppliers, safety stock and coordination among actors are important factors in fulfilling these quick demands. For example, Rt1-C1R1 and WS1-C2R2 highlighted the importance of human resource backup in fulfilling the demands of relief providers, "…*last year we got the order from one of the NGO, they also wanted the product in special packaging, we have trained special labour for this which we call only for this purpose, we pay them higher amount but get our work done on time*". This speed of response is important in achieving network resilience.

The distribution of relief items in these regions is often a major problem. Typically, there are many donors and individual agencies who wish to contribute to relief efforts, but the in-

country agencies often cannot handle everything on their own. Indeed, this research has found a number of instances where some of the actors, especially superstores, are involved in distributing relief products to the affected areas themselves. One retailer describes it this way, *"in some cases what we have done is that we get orders and we make those hampers and supply those hampers directly to affected areas... but 90 to 95% cases we give to suppliers and then they distribute via their own distribution networks or via third party systems whatever is their system. Hamper is basically a box... where there are 2 kg rice, 3 kg sugar, 2 kg ghee and spices are added in to that box... basic commodities for relief… that one may eat for a week"* (Rt1-C1R1). By becoming a dual channel, these local food supply chains greatly enhance the responsiveness of the overall network to disasters, thus enabling resilience. There were other cases of this dual flexibility where relief providers distributed food coupons to the local population who could then exchange these tokens for food from local retailers. Another form of flexibility was noticed where these local food chains provided discounted and free products to relief providers. As one commission agent explained, "*We are flexible about the prices in difficult times, especially when some companies who provide relief in these areas they come to us then we give them discount, and we also give them free considering that this is also our responsibility"* (CA2-C1R2). Hence, collaboration with relief chains also markedly enhances the overall resilience of these food networks. This analysis has found considerable interactions and collaboration between these chains and this is clearly linked to increases in flexibility, adaptability and velocity.

6.1.3 Discussion on Collaboration

Collaboration is one of the main areas that is crucial in disaster management (Kovács & Spens, 2011). Similarly as the number of disasters increases (Howell, 2013), there is a corresponding multiplication of the frequency of supply chain disruptions (Van Wassenhove, 2006). Therefore, supply chains that are deemed resilient possess such capabilities as agility, adaptability and alignment and these are of great interest (H. L. Lee, 2004; Pettit et al., 2010; Ponis & Koronis, 2012). This research has provided empirical insight into the key components of collaboration and highlighted some of the important activities that contribute towards supply chain resilience.

There are several collaborative activities that occur in supply chains. These include information sharing, resource sharing, communication and incentive alignment (M. Cao & Zhang, 2012; Scholten & Schilder, 2015). Collaboration also happens at both vertical and

horizontal levels (Scholten, Sharkey Scott, & Fynes, 2014), and was evident in this analysis. At the vertical level, collaboration happens among supply chain partners such as retailers, wholesalers, processors and growers, while at a horizontal level it occurs within-groups of competitors, government departments and relief providers.

Effective communication and information sharing is one of the most important components of supply chain collaboration. Relationships between supply chain partners depend on information that is visible across the supply chain (Holweg & Pil, 2008), particularly, information about disruptions or any changes in the supply chain. This information can only be acquired by communicating with the other supply chain members. It also allows supply chain members to have advanced warning of events and hence make appropriate preparations (Ritchie & Brindley, 2007). This analysis has found that information sharing and communication is achieved primarily through effective use of telecommunication, site visits and above all, mutual dependency through tight social relationships.

Telecommunications and media are very important for effectively dealing with natural disasters, especially when traditional communication channels (print and broadcast media) are mostly lost (Abe & Ye, 2013). This early communication ensures flexibility in the supply chains and allows them to respond to difficult situations (Barnett & Pratt, 2000). Analysis of the data shows that site visits by key coordinators increases the visibility of different organizational processes. Having visibility leads to more resilient supply chains, as this enables quick decision making based on prior knowledge and data. This finding is also in line with the findings of Scholten and Schilder (2015) who also has advocated the importance of visibility in supply chain resilience.

Mutual dependence is a necessary attribute which contributes to communication and information sharing among supply chain members. This finding confirms the verdict of Soosay, Hyland, and Ferrer (2008) who argue that it is because of mutual dependency that different firms in supply chains come together to deal with disruptions during the natural disasters. Mutual dependency helps these networks adapt to new situations quickly, as they are bound to help each other because of common interest. However, Scholten and Schilder (2015) argue that mutual dependency increases dedicated investment, which in return, decreases flexibility. Yet this analysis found that resilience actually increased, and this is due to there being no other major (institutional) financial support available to these supply networks.

Indeed, one of the most significant findings for the concept of collaboration, leading to increased supply chain resilience, is the non-institutional financial support available in these regions. This finding is rooted in the resource dependence theory where powerful firms, in a supply network, meet less powerful partners' needs in a mutually beneficial arrangement (Min et al., 2005). These powerful actors (in this research located in the main wholesale markets or hubs), provide financial support to both upstream and downstream members of the network. Nevertheless, this may decrease flexibility due to path dependency, as mentioned in the above findings. However, in terms of credit return and lead time, these findings show that it increases flexibility. In addition to flexibility, this research also argues that alignment, adaptability and velocity of response also increase due to the availability of this non-institutional financial support to small holders and those impacted by disasters (Gligor & Holcomb, 2012; Mentzer et al., 2001).

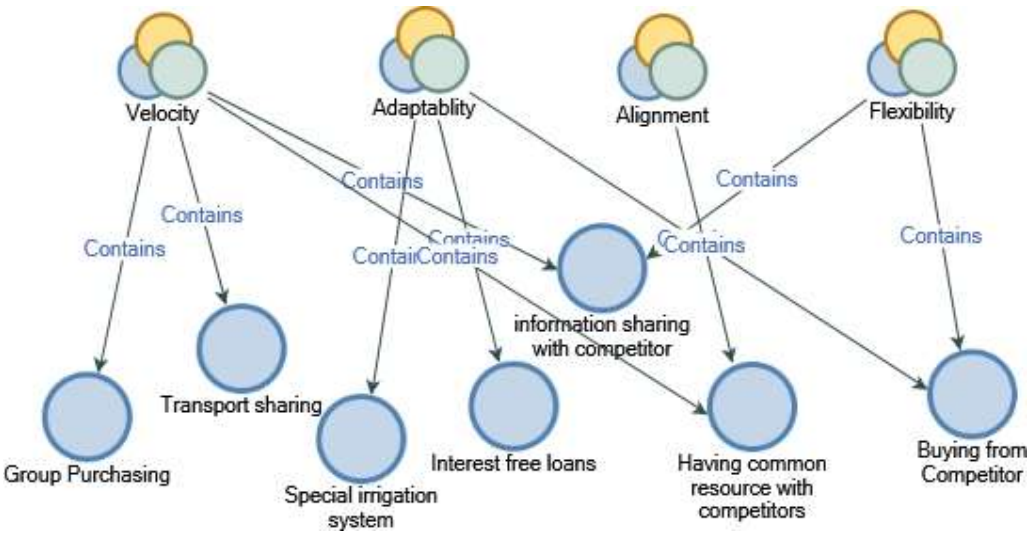
Linked to these non-institutional support providers, another important insight relates to the role of a chain coordinator or lead actor in facilitating collaboration among the partners to achieve supply chain resilience (Akhtar et al., 2012). This phenomenon is mostly discussed in humanitarian chains, where financially strong relief providing organizations play the role of chain coordinator, but in terms of food chains is also significant. In commercial chains, these could be large-scale retailers and distributors (Belaya, Gagalyuk, & Hanf, 2009), however in this study, independent actors in hub markets, as a closely aligned inter-dependent group, are the main chain coordinators. They provide financial support to the less powerful members of these chains in both regions. As Akhtar et al. (2012) point out, chain coordinators act as a catalyst, thus ensuring the effective coordination among different supply chain members and this coordination contributes to agility, alignment and adaptability of these chain actors. This research confirms this finding, and argues that it is the close social networks, cultural norms and mutual dependency created through the financial support of the chain coordinators, and by their commitment to other actors that make these supply chains aligned, agile and adaptive.

Stevenson and Spring (2009) argue that inter-firm information and resource sharing leads to supply chain flexibility. Indeed, this analysis confirms this finding as labour and transport sharing is very common in all four supply chains. Subsequently, the analysis has also highlighted that this practice not only facilitates flexibility, but also increases the velocity of operations due to resource sharing, thus leading to more resilient supply chains.

In addition to the reasonably well-coordinated vertical collaboration, horizontal competitors are also found to share resources and information, supporting each other financially and seeking common solutions. This phenomenon of simultaneously competing and collaborating with competitors is often described as 'coopetition' (Bengtsson et al., 2010b). In this study, drivers of coopetition are mostly contextual. This analysis confirms that network dynamics push organizations to cooperate with their competitors in order to survive disasters (Gnyawali & Park, 2009). It can also be called 'emergent coopetition' as it arises mostly in difficult times (Kylänen & Rusko, 2011). However, this research also observed some structural coopetition that takes the form of more planned coopetition driven by the buyers in these supply chains (Pathak et al., 2014). This structural coopetition has been observed in this research as well where buyers urge the two otherwise disconnected suppliers to collaborate with each other through training programs.

Scholten and Schilder (2015) have stated that collaborative activities between competitors leads to flexibility and velocity in supply networks. This research found that besides increasing flexibility and velocity, coopetition helps achieve adaptability through financial support and supply chain alignment via the sharing of information. Therefore, these findings confirm that supply chains resilience can be enhanced through coopetition. Figure 6.5 below shows the association of activities present in the coopetition theme and their association to the supply chain resilience components.

Figure 6.5 Association of Coopetition with Supply Chain Resilience Elements



Source: Developed by the Author

Furthermore at the horizontal level, this research has found that government support and collaboration with relief providers are important components of supply chain collaboration. Cai, Jun, and Yang (2010) consider government support as an important element of collaboration within supply chains. This is especially true at the local government level because they have a more direct influence on business activities by forming and implementing policies.

Government support is also considered to be crucial in disaster management literature in order to meet the challenges of natural disasters (Balcik et al., 2010; Van Wassenhove, 2006). Government support assists velocity in relief efforts as well as helping organizations to adapt to new situation, by supporting them financially and through improved infrastructure, in both the preparation and recovery phases. This improved infrastructure is crucial for coping with future disasters as well. This research also confirms that government support in food supply networks is a major contributing factor for adaptability, velocity and reliability, thus increasing supply chain resilience. However, there are greater vulnerabilities associated with this activity, including corruption, poor policies, poor planning and the undue influence of strong parties. If these things are improved, it will greatly enhance the overall resilience of these chains.

In addition to government support, collaboration with relief providers is also an important aspect which is highlighted by in much of the disaster management literature (Akhtar et al., 2012; Day et al., 2012; Maon et al., 2009; Roy et al., 2012). This research foregrounds the role of the retailers and wholesalers in a disaster area, as they are often the first or only responders (Garry, 2005; Horwitz, 2009a). Interestingly, they also help in distributing relief items on behalf of the relief agencies in the affected areas (Cozzolino et al., 2012). This finding is confirmed by the present study. The interaction between these two chains is twofold; one where local food chains facilitate and help the relief process, and the other, is where relief chains help local food chains. The local foods chains have assisted relief chains in the past by establishing local procurement operations with retailers and wholesalers, quickly fulfilling relief demands, and vice-versa with relief providers restoring infrastructure and supplying situational awareness through sharing information. This research argues that all of these activities make the overall food supply chain network more flexible and adaptable, thus contributing to food supply chain resilience. However, there is general lack of trust present among these players and also local food chain actors will often take advantage of relief providers by supplying low quality products at high prices. Government and relief providing organizations should interact more

with these local actors through seminars, print and visual media and where appropriate, applying sanctions for profiteering during disasters. This interaction will create more awareness, build relationships and in this way, both chains can work together and enhance the overall resilience of the regions as well.

Finally, building and maintaining trust is essential, because without these, both vertical and horizontal collaboration is impossible. This research has previously identified mutual dependency of actors as a driving force towards collaboration. Additionally, this mutual dependency is driven by the trust in these relationships. Many authors have discussed trust as the building block of supply chain agility, as it helps visibility, reliability, velocity and flexibility (Narasimhan, Mahapatra, & Arlbjørn, 2008; Yang, 2014). This research finds that building and maintaining trust mostly originates from social norms within these regions, and that high levels of trust helps to achieve agility, adaptability and alignment. The most important finding in this component is the conflict resolution mechanism discussed in the findings section. This conflict resolution process (Jirga and the market committee), provide a high degree of confidence within these chains and ultimately builds trust. Conflict management during natural disasters also enables flexibility and velocity, two important factors for disaster responses. Nevertheless, conflict management is an important activity as many conflicts arise during difficult times in these food chains. Yet due to the incompetent and slow formal judicial system, actors prefer to resolve their issues using the Jirga as the more efficient alternative dispute resolution system. However, this system has also its own flaws, such as decisions influenced by parties who have more financial power, weak decision-making processes and non-acceptance of decision by the parties. The provincial government has made moves to provide it with legal status by establishing dispute resolution committees, but the process is slow. If the Jirga system can gain full support from the government, then this could enhance the overall conflict resolution status of these supply chains.

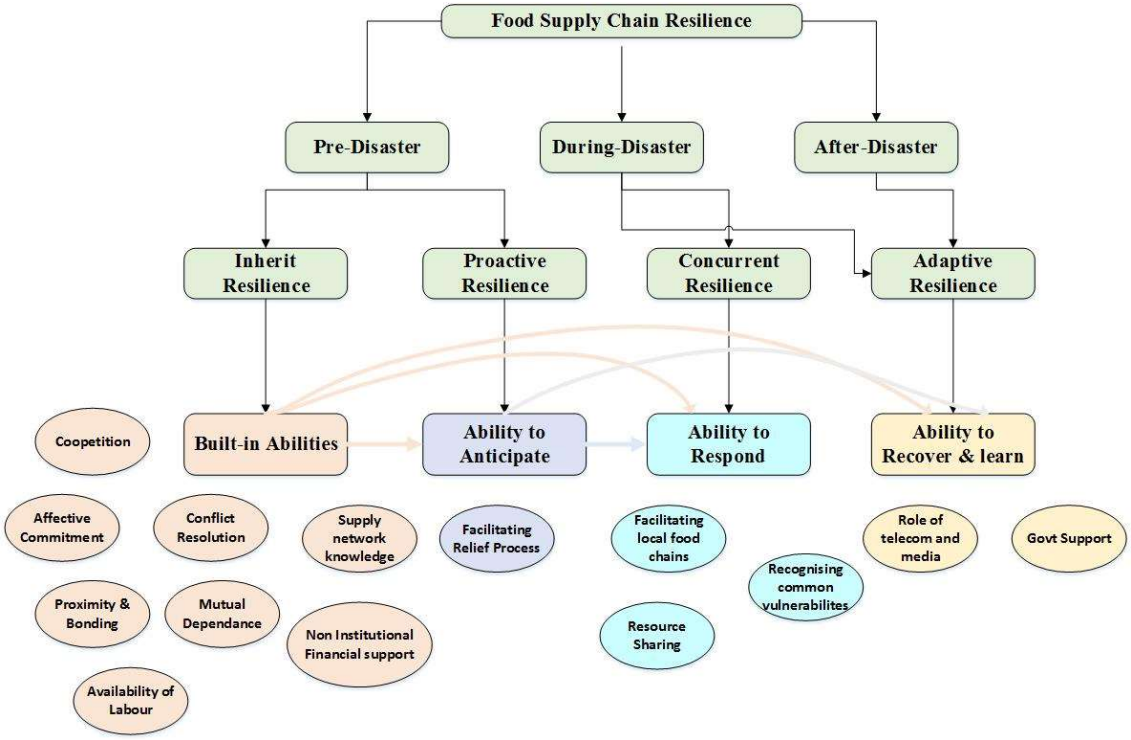
Overall, the contribution of supply chain collaboration towards supply chain resilience can be seen as positive. Both vertical and horizontal collaboration increase supply chain resilience by enhancing agility, adaptability and alignment. The findings of this research are also in line with the relational view of RBV where it has been found that collaboration itself is also a key capability with number of different activities. This capability is achieved through the interaction of different supply chain members and contributes towards supply chain resilience.

Furthermore, an important point is that most of the activities identified in this research under the concept of collaboration, are actually part of the 'inherent' resilience of these food supply chains. Inherent resilience, as explained in literature review, are the extant or built-in capabilities of the system, developed prior to events, that help the supply chain to deal with disruptions (Cutter, 2016; Tierney, 2007). This research has identified these factors as coopetition, conflict resolution, non-institutional financial support, mutual dependence, commitment, proximity and bonding and the availability of labor. All of these pre-existing factors are key parts of the concept of supply chain resilience and are inherent properties of all of the four food supply networks. An interesting aspect of this research was that during the data gathering phase, many of the respondents were totally unaware of the supply chain resilience phenomenon. Indeed, they do not set out to achieve supply chain resilience of itself, but rather prepare themselves to survive the disaster by taking actions that preserve, as much as they can, their livelihoods, investments and assets. Given the high frequency of disaster events in all four supply chains, these actions seem natural and normative to the actors, but are still essential for survival during disasters. Due to these inherent capabilities, they generally respond and recover from natural disasters fairly well (see Figure 6.6 below). Indeed, given the frequency of disasters in both regions, it can be argued that these food chains would naturally possess a number of resilience qualities that make them ideal to study.

Similarly, a few of the activities are part of concurrent resilience (see the literature review for more details) that is resilience in the response phase of the disaster, or the ability to respond to disruptions. This research shows that facilitating local chains, recognizing common vulnerabilities and resource sharing are part of concurrent resilience (Ali et al., 2017). Government support is also a key activity in terms of supply chain resilience, however, this has been included in the adaptive resilience/recovery phase. In addition to government support, the role of telecommunication and media are critical in adaptive resilience and the recovery phase of a disaster. Nevertheless, major adaptability comes from the inherit resilience activities, and these two activities directly increase adaptive resilience. However, most of time there is a general lack of proactive resilience (actively anticipating and preparing for disaster) in these supply chains. Currently, there is only one activity included in this section (that is, facilitating relief process), where supply chain members actively prepare for disruptions as they have to fulfil the demands of relief chains providers who plan ahead of

disasters. Yet, this practice would be more for commercial motives rather than deliberately building resilience.

Figure 6.6 Mapping of Collaborative Activities to Resilience Dimensions

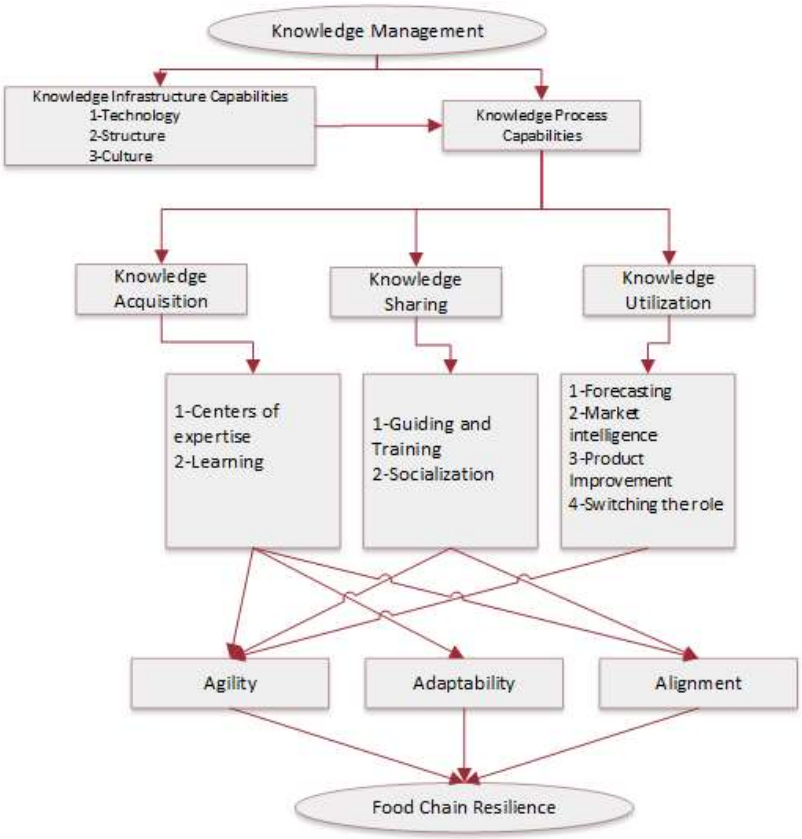


Source: Developed by the Author

6.2 Knowledge Management

Knowledge management (KM) is the second critical area in disaster management/relief supply chain discipline (Islam & Chik, 2011; Pathirage et al., 2012; Van Wassenhove, 2006). KM can enhance supply chain resilience through infrastructure and robust processing capabilities. KM infrastructure includes the technological, structural and cultural aspects of these networks that are crucial for KM process capabilities. These capabilities include; knowledge acquisition, knowledge sharing and knowledge utilization. The following section will discuss the findings related to the underlying activities in each of these areas and how they relate to the components of supply chain resilience, that is, agility, alignment and adaptability. Figure 6.7 shows the underlying activities of KM and how these relate to supply chain resilience.

Figure 6.7 KM Activities Leading to Supply chain Resilience



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6.2.1 KM Infrastructure Capabilities

KM infrastructure covers the environment in which these supply networks operate. Pandey and Dutta (2013) note that KM infrastructure incorporates those things that facilitate the flow of knowledge to support the activities, tasks and decisions within the network. There are three main substructures related to KM; technology, structure and culture. All three contribute significantly to achieving effective KM in the food supply chains of this study.

6.2.1.1 Technology

Technology is the mechanism within these supply chains that helps to create, share and use the knowledge to deal with difficult situations. In terms of technology, R1 is more advanced, especially in terms of online databases for the crop management, and other up-to-date information. In R1, there are some dedicated websites run by the local government to facilitate KM to supply chain members. In terms of telecommunications, both R1 and R2, have advanced technology, especially for cell phone coverage, that can reach all areas (even small

outlying villages). In the event of natural disasters, mobile phones are the primary means for sharing and retrieving information needed for a speedy response. One respondent stated *"…we mostly contact our suppliers and buyers over the cell phone which really help us to share the important information with each other, there are websites and other information systems mainly in our region which give us useful information to stay up-to-date with the latest trends"* (WS3-C2R2). The role of social media is also gaining in popularity in both of the study regions. However, this is mostly restricted to NGO's and well-established companies that use social media, to spread the awareness of disasters to the general public.

Apart from mobile phones and databases, warning systems have also been installed at many critical locations by the government in both the regions. Early warning systems about floods are crucial in order to allow precautionary measures to be taken by these supply chain actors. The NDMA (National Disaster Management Authority) also uses a Geographical Information System (GIS), and remote sensing tools, to map the areas and survey the impact of a disaster, to allow for effective logistics operations in these areas. However, while mobile phones and social media are important means of sharing information and knowledge and are critical in responding to disasters, the telecommunication infrastructure is vulnerable and is dependent on continuous investment and development. As such, while telecommunications contribute to the resilience of these supply chains, it can also be seen as one of their major vulnerabilities. As earthquakes are more frequent in R2, infrastructure is thus more vulnerable here. In contrast, R1 is more predisposed to floods and therefore its infrastructure is less vulnerable, as floods generally have more specific routes and can be predicated earlier. Further, mass media is also very popular, especially in R1, as there are more than 50 news channels in operation and these mostly have a positive role in providing information and awareness to supply chain members. However, timeliness and accuracy of reporting can be issues.

Indeed, due to the generally low literacy rates in both of the regions, supply chain members often do not have direct access to this information. It is suggested that structure (relationships and physical flows) of these supply networks plays an important role in acquiring and disseminating knowledge, in essence word-of-mouth knowledge transfer is seen as the most reliable.

6.2.1.2 Structure

Network structure can be defined as sets of rules, procedures, reporting relationships and boundaries between member firms of a supply chain network (Reagans & McEvily, 2003). This study has seen that three out of the four supply chains possess 'hub' nodes or areas that consist of many independent firms residing in the same geographical location, operating under a single governance structure (discussed later in this chapter). Buyers and suppliers are connected to these hub areas in many ways. These hub areas can be considered as strong facilitators of information sharing, financial support and other important elements discussed in the previous section on collaboration.

The members of these hubs are closely knitted into these networks and bound by a strong cohesive force, derived partly from the fact that many of these are family businesses, as well as the impact of the local culture. These hub structures enable knowledge generation and sharing, and also allow supply chain members to adapt to new situations after a disaster. As one responded noted; *"…because we are working in the wholesale market and we were farmers before, we have the knowledge of different aspects of business, this market structure helps us to easily switch our business and also sometimes we deal in multiple products and diversified products to help sustain in this business"* (WS3-C1R1). The preceding analysis shows that besides technology and structure, culture is also a very important variable in leveraging KM.

6.2.1.3 Culture

In this research, culture is defined as the beliefs, customs, law, morals and any other habits in common, displayed by supply chain members in these networks. The culture within these networks is naturally parallel to the general culture of the host society. This research has found that a culture of sharing is prevalent in these networks. Although elements of trust are very difficult to establish, as people tend to believe rumours and other misinformation. However, once trust is established then it supports all other elements of the network. Due to the chain structure, at some stage, all members visit the same wholesale market where they interact with each other, socialise, share experiences and conduct business. There are no other formal forums available whereby they can interact to the same extent to share information. As such, due to the high level of face-to-face interactions, common language and mutual dependency,

a culture of creating and sharing new ideas has developed over time. These factors strongly influence supply chain resilience.

This study has found many instances where respondents reported that most of the businesses are family oriented and how they help each other in times of disruptions. As one respondent stated, *"…we have mostly family business, everyone is associated with each other and in our religion, we also consider other as our brother, therefore it helps to share information with each other also helping each other to survive and get back to their feet"* (WS3-C2R2). The religion (Islam) is also a significant part of the culture of both regions and plays an important role in achieving this culture of respect and sharing. Most individuals involved in these networks are conservative, religious people. Many believe that religion is the force behind natural disasters. However, there are also many problems associated with this sort of rationality, such as many members do not prepare adequately for the disasters as they consider it a religious matter. As such, a strong streak of fatalism hinders the development of more resilient supply chains.

6.2.2 KM Process Capabilities

Knowledge can be divided into tacit and explicit knowledge (Nonaka, 2008). This study has found that in these networks, most knowledge is tacit knowledge (that is, it resides in the experiences and minds of the members). In the KM process category, this research has found the following methods of knowledge acquisition, sharing and utilization in these networks all contribute toward supply chain resilience.

6.2.2.1 Knowledge Acquisition (KA)

Knowledge acquisition is the process of acquiring knowledge before a disaster, during or after any disruption. This study has found that generally speaking, there are two main ways that knowledge is acquired; firstly, through centres of expertise, and secondly, by learning.

6.2.2.1.1 Centres of Expertise

Centres of expertise are the focal points within these networks, where the desired expertise in the relevant fields resides. Information and knowledge flows from these centres to the networks. In turn, this can be used to manage difficult situations. Agricultural research centres are present in both regions studied. Generally, these centres possess up-to-date knowledge and are able to disseminate knowledge to many supply chain actors, due to improved IT

infrastructures. One of the respondents noted the way that knowledge on crop research helped in adaptive resilience (a new strain of resistant seeds was released that were able to better cope with flooded areas), *"…with latest research now lots of vegetables are available throughout the year, similarly researchers have also found a form of rice which can survive extra amount of water and excessive rain and doesn't damage it"* (Fr2-C2R1). Government departments, such as NDMA, PDMA, and other local governments, conduct research in the affected areas. Therefore, the information is thus perceived as more accurate and reliable in these chains. One example of this thinking is "…a*s the information about latest trends and natural disasters comes from government departments, therefore we can rely on it"* (CA2-C1R1). Many respondents had a good understanding of the natural disaster life cycle and perceived that the functionality of critical government institutes is helpful in natural disasters. This trend was more widespread in R2 as this area is more prone to earthquakes and floods. On the other hand, there were many respondents who criticised the role of these institutes. This criticism was mostly in terms of the favouritism of these institutes towards politically and financially strong actors.

6.2.2.1.2 Learning

The second source of KA is learning. Learning through disruptions brings critical knowledge to these networks, which in turn helps them to better plan for the next, almost inevitable disruption. This research has found many examples of learning during and after disasters in these networks. Indeed, it is thought that the culture and structure of these networks fosters the learning process.

Most of the learning by supply chain members comes by experiencing a situation or through others who have experienced a similar incident in the past. This study has observed many incidents of learning new methods by these members, who then challenge or modify existing knowledge to deal with the new situation. For example, members of hub markets learnt over time that coordination with competitors is beneficial (as explained earlier with coopetition) and helps them all to cope with disasters.

Learning in disasters is a strong enabler of adaptability, alignment and velocity in these supply networks. One of the respondent in C2R1 recalled how learning through their experience helped them to better adapt to new situations, and have protected them from future similar events, *"…we improve it time to time e.g. as I told you that we have sewerage system to drain*

the rain water so that the rain water goes out to a bigger canal. Similarly, rather than soil we have their brick powder which is called "kery" it is there. It does not cause slippery or marshy land. It withstands. According to firefighting approach and learning experience we have done all these things" (Pr1-C2R1). Although this example is related to the rainy season in general, it shows that there is a trait for learning from experience, which will inevitably help in disruptions arising from natural disasters.

Similarly, learning new skills and having situational awareness, helps align the interests of different members in these supply chains. Two of the wholesalers from both of the regions explained how they learnt about procedures to import products from overseas in order to cover disasters, *"We imported the fresh produce from India, because of severe weather in Sindh province, our supplies were zero, this new produce was expensive but our buyers both wholesalers and retailers understood that it is need of time to survive in the market, therefore they understood, no doubt profit was low but we survived"* (WS2-C1R2). This learning brings adaptability and alignment that makes these supply networks more resilient to future disruptions.

Learning by experience during the response phase of disasters, was also helpful in coping with new, unexpected situations. This quickness or velocity is crucial for the overall survival of the study's supply chains. As one respondent explained, *"…we had a visit in all areas when there was flood. We took a boat and with rescue we went for a round. We saw places where there was not water in certain areas. Also PDMA helped us give up to date information, we were able to quickly adapt to the new situation, we imported items for other areas and helped our farmers to get to their feet again"* (Br1-C2R1). Yet, KA itself is not enough for the survival. This knowledge needs to be shared and utilized in order to make it more effective.

6.2.2.2 Knowledge Sharing (KS)

Knowledge sharing is enacted in two different ways. One is a more formal method by which supply chain members guide and train other members. The other one is via socialization, an informal way of knowledge sharing that is facilitated by the structure and culture of these networks.

6.2.2.2.1 Guiding and Training

This study has already addressed collaboration in terms of site visits by buyers and suppliers. But adding to this is the idea that guiding and training are more formal methods of facilitating KS. The nature of knowledge here is mostly explicit when training is given. Knowledge transfer, however, is more tacit in nature such as when general guidelines are shared with suppliers or buyers. The research shows that the information is provided to suppliers concerning how they can improve their processes and benefit the whole chain. As one respondent explained, *"…we guide our suppliers about their sourcing strategies, this increases the quality of the product and also prices are less which leads to increase sale"* (Rt1-C1R1). This makes the supply chain more reliable, thus leading to supply chain resilience, as reliability is necessary for agile operations.

One of the fundamental advantages of formal guiding and training is to have the alignment among the supply chain partners. When interests and processes are aligned, supply chains are in a better position to respond to disruptions. A respondent provided another example, *"…our Quality Assurance department does not only go to check him but to guide him as well... that you might increase the sale by improving these things... we guide him about let's say you are giving me 120 rupees and another is giving me 115 rupees then we guide them that may be your sourcing is not right... maybe you are taking stock from somewhere not appropriate... you might try to take from these several places"* (Rt1-C1R1). Here the retailer has more knowledge through advanced technology and is making sure that suppliers are aligned to its procurement needs.

6.2.2.2.2 Socialization

This study found that most of the knowledge sharing is achieved through a socialization process. As such, tacit or indigenous knowledge derived through experience or centres of expertise is shared through social contact and relationships with other members of the network. The exchange takes place between suppliers and buyers through sharing experiences. This increases the visibility and aligns the processes of the concerned parties. This process is explained in the following example, *"…upstream and downstream partners come to visit market regularly, they exchange information and also come to know about each other processes"* (CA2-C1R2). Not only do the dyads, but the whole network takes advantage of this socialization that occurs at wholesale market (hub) level. This level of knowledge

sharing, prior to disaster events, is especially useful during and after disasters in order for businesses and families to survive.

The data analysis shows that socialization is the stem in the structure of these chains. Indeed, this research has reported an increase in the levels of socialization of the three chains that have hub-based structures. However, the fourth case, C2R2 does not have a hub structure, and not surprisingly, less socialization was observed. As a consequence, there were more episodes of poor or outdated levels of information being held by different members in this supply chain. This makes them less resilient to disruptions arising from natural disasters.

6.2.2.3 Knowledge Utilization (KU)

It is one thing to possess knowledge or information, it is another to use it. In this research, information acquired and shared by supply chain members is used for forecasting, preparation for future disasters, effective response, market intelligence, product improvement or developing strategies to cope with, and recover from, disaster. This knowledge becomes the building block of collaboration, logistics practices and sourcing strategies in difficult situations. KU directly contributes to the velocity, reliability and flexibility components of supply chain resilience.

This research has postulated that forecasting is the most crucial element of knowledge utilization. Forecasting is essential to prepare and respond to disasters. In this sample, forecasting is based on experience, historical data and occasionally, using computer software. These forecasting methods help these networks to be responsive and increase the velocity of response. For example, one of the respondents noted that, *"…in events of natural disasters, there is a shortage of food items in the market and prices become high. He knows his customers demand so he procure accordingly*" (LP1-C1R2). Another respondent in C2R1 told us about the role of forecasting in achieving velocity, *"main customers of this rice mill are air force, navy, rangers, Punjab Police, Army, utility stores and Hajji Camp etc. they have annual contract. Contracts are with the beginning of the season, for instance this is the beginning of the season then think that there is no more paddy in the market and they have their orders. They know that we have to send this much stock in the army on monthly basis, because of their efficient forecasting"* (Br1-C2R1). The increase in responsiveness is achieved through these forecasting measures. It helps to build supply chain resilience, especially given the regular recurrence of flooding in these regions.

Reliability and flexibility are another two factors that can be achieved through the proper use of knowledge gained through socialization or other means in these supply networks. Product improvement has been quoted by many respondents as one key means of increasing the reliability of these chains. For example, *"…seed adapts according to the land after 2 to 3 years... after 3822 type there was basmati 2000... its height used to be too much... it used to fall on land... its plant used to spread... those who are common grower even they have 35 to 40 yields... they take more yield because… because they rely on latest product development and research"* (Fr2-C2R1). Having multiple roles, or the ability to easily switch roles by the members of these supply chains also originates from having a good knowledge concerning the functionalities of the markets. It is clear from the data that the supply chain structure is the biggest contributor to this process, as it allows members to have multiple roles in the market. Utilizing knowledge helps supply chain members to cope up with disasters on a short-term basis. One middleman shared how he became a commission agent in C1R1 during a disaster and how this helped him deal with the situation, *"…in case of adversity we sometimes buy few items within the market and sell the products further to retailers or whole sellers based on the contacts we have established in the market"* (MM1-C1R1). There were other instances where dual roles were observed in the supply chain. This level of role flexibility is quite unusual and means that the same actors can perform different functions, not only at the horizontal level but up and down the vertical tiers as well, therefore dealing with disasters efficiently and achieving supply chain resilience.

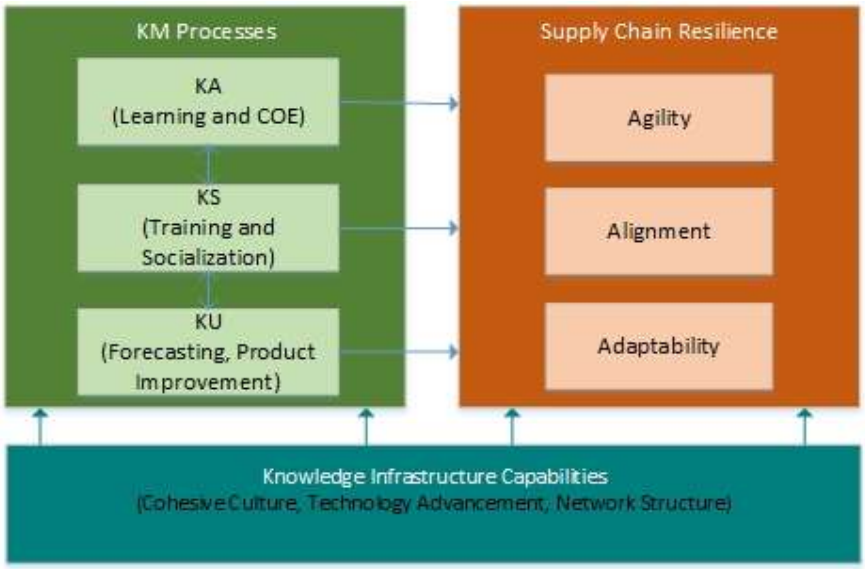
6.2.3 Discussion on Knowledgement Management

The findings of this research have shown that knowledge management is important in order to improve agility, adaptability and alignment within these supply chain. Knowledge management has been highlighted as a key area in disaster management literature (Ajami & Fattahi, 2009; Collins & Kapucu, 2008; Dorasamy et al., 2013; Kovács & Spens, 2011). This research has added to the current literature by providing insights into the nature and structure of knowledge management. It has argued that, in combination (nature and structure), KM helps contribute to effective disaster management and increase the overall resilience of these networks.

In this analysis, KM infrastructure has been treated separately from the KM process capabilities as suggested by Bharadwaj et al. (2015). KM infrastructure is seen as the building

block for effective knowledge management in these networks. Not only do KM processes in these two regions contribute positively towards achieving adaptability and velocity in these chains, but so does the infrastructure of culture, structure and technology. Choy Chong (2006) and Chua (2004) foreground the role that technology plays, especially IT (website and information systems) and telecommunications in KM. The findings of this study confirm that the main medium for knowledge and information sharing is the humble mobile phone in all four case studies. Furthermore, a culture of sharing and respect also significantly facilitate KM processes. The bulk of the sample were family businesses who learn together and share information that helps them to adapt to new situations, and also prepares them for future disruptions (Holsapple & Joshi, 2000; Pan & Scarbrough, 1998). These findings confirm Zaied (2012) assertion that a sharing and collaborative culture ensures efficient knowledge processes. This common culture, while significant in this sample, may not be present in other disaster response situations where multiple actors from many different countries are present.

Figure 6.8 Interaction among KM Processes, Capabilities and Supply Chain Resilience



Source: Developed by the Author

While culture is significant, this study has also found that network structure plays the most crucial role in facilitating KM processes and helps supply chain members to adapt to disruptions. Network structures that are cohesive and collaborative materially aid in speeding up the knowledge dissemination processes (Reagans & McEvily, 2003). The structure of these supply chains shows the presence of hubs that also act as 'knowledge hubs'. These are

described as such because the bulk of the attached buyers and suppliers visit these markets regularly and interact with each other. Here knowledge transfer is materially aided by the socialization and culture within these hubs. Also, authoritative government representatives are also present in these hubs lending credibility to the knowledge source, and hence further facilitating the KM process. Further analysis shows that wherever there are strong inter-organizational ties present within these networks, the learning and knowledge transfer processes are more efficient.

The other main finding is related to KM processes. Although knowledge management is processed in a variety of ways, this research has discerned three distinctive processes at work within these supply networks. These are knowledge management acquisition, knowledge sharing and knowledge utilization. Indeed, the boundaries between the three are blurred, as these processes often occur simultaneously, especially learning and sharing. The data shows that these are not linear processes, rather they are iterative processes that develop distinct patterns of interactions over time. Learning sometimes involves sharing knowledge with other members. However, this study has presented these finding in three separate categories in order to provide insights into this important contributing factor of supply chain resilience.

First of all, most of the knowledge is tacit in nature in these networks, especially at the vertical level among supply chain actors. However, at the horizontal level (where government agencies and relief providers are involved), knowledge is present in both explicit and tacit forms. Tacit knowledge is intangible in nature and mostly resides in the routines and minds of the people (Dorasamy et al., 2013). Similarly, most of this knowledge is indigenous knowledge (IK). IK is a form of knowledge that is practiced, maintained and developed by local people or communities. In this study, the individuals involved have an extended history of interaction with each other and with the phenomenon of natural disasters (Agrawal, 2014). The hubs in these supply networks can be viewed as a community within a community, where different organizations and people have been associated with each other over a long period of time (sometimes even over generations). The data shows that they rely on both scientific knowledge (from research) and traditional indigenous knowledge. This knowledge is also tacit in nature and collectively owned by the community. Hubs provide the opportunity for these stakeholders to come together and share this knowledge, thus surviving the negative effects of disasters collectively. Each of the three knowledge processes are discussed below.

Knowledge acquisition is a primary process. This study found that centres of expertise (COE) and learning are the two most important ways to acquire this knowledge. COEs such as research institutes, government agencies and other relief providers are the main source of knowledge before, during and after disruptions. Warning systems, infrastructure improvements, and information about new methods of agriculture all help supply chain members to effectively deal with disasters. The role of warning systems and new techniques in agriculture is also emphasised by many researchers (Bartos & Balmford, 2011; Collins & Kapucu, 2008). This information is viewed as authoritative; thus, it underpins reliability in products and operations of these networks. Similarly, it helps farmers to adapt to new situations, and provides information about issues such as ways of storing and saving crops. However, there were many shortcomings recorded in these practices. Often information was not up-to-date, while at other times, there were inconsistencies in the information, that increased vulnerabilities. Lack of awareness (related to these elements), was also a major issue in these supply chains and occurred mostly at the production/farmer level. If the governments in both regions can create more awareness and support initiatives to decrease inconsistencies in the information, it will positively contribute to the overall resilience of these supply chains.

It is argued that the most important element in disasters is 'learning' (Barnett & Pratt, 2000; Choy, 2006; Lu et al., 2013). It is a constructive and critical factor in responding to disruptions arising from natural disasters. However, there are no formal mechanisms present in these supply chains for learning. Rather, most of the learning comes from actually experiencing the events. There are other forms of learning, such as learning from other similar actors, learning from actively searching, and learning from examining the external environment. Indeed, Huber (1991) & Tsang (2002), Lu et al. (2013) have proposed learning mechanisms for relief providers during natural disasters. These are, learning by hiring (grafting learning), learning by doing (experiential learning), learning by observing (vicarious learning) and learning by searching (searching). While this research has found three of these learning mechanisms in these supply network, most of the learning comes through experience (learning by doing), or when members actually face disasters. Learning from similar organizations (learning by observing) is also very common, as is learning by actively participating and searching the external environment (learning by searching). According to Lu et al. (2013), active searching is

done during the preparedness phase. However, this study found that it is present in the response phase as well, mostly in the form of damage and situational assessments.

Learning during these disasters helps these supply chains in terms of adaptability, as they learn new ways of dealing with these situations. They are therefore more prepared to face challenges emerging from future natural disasters (Kovács & Spens, 2007). Government departments learn more efficient and effective ways to respond to disasters. They also improve the infrastructure and spend more money on the latest research (such as seed technology and better building standards). Learning from similar organizations and especially from supply chain members, helps to align the processes and interest of these supply chains. This, in turn, results in higher levels of responsiveness (Dove, 2003).

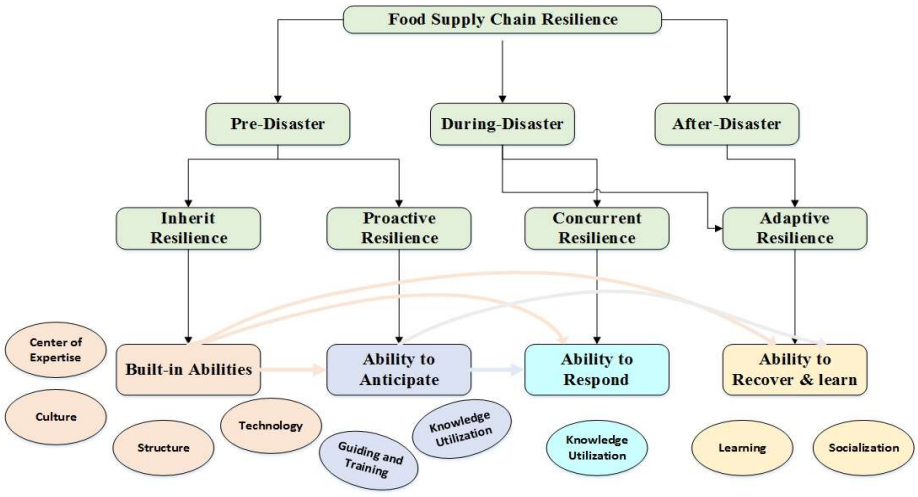
After knowledge acquisition, the next process is knowledge sharing. Here the knowledge infrastructure facilitates the process. There are two ways by which knowledge is shared in these chains; one is formally through training and guidelines provided to suppliers, laborers and other members. The other includes more informal mechanism of socialization and collaborative interactions, where different parties come together and interact with each other to share knowledge. Training and guiding the suppliers originates from the extant collaboration between two parties. It helps to align the processes and enhances the reliability of these supply chains. It is primarily at the wholesale markets where buyers and supplier interact with each other and share their tacit knowledge, a form of tacit-to-tacit knowledge exchange (Bharadwaj et al., 2015). This coming together, sharing of insights and transferring knowledge increases the absorptive capacity of supply chain members, thus making them more adaptive (Harri Laihonen, 2015). As socialization is the mechanism for supply chain member interactions, it also helps increase situational awareness of events and thus, increases visibility within these supply chains (Barratt & Oke, 2007).

Finally, knowledge utilization is where supply chain members, who have acquired knowledge and/or shared it, actually apply it as demonstrated through tangible actions and decisions. Such knowledge can be used to enhance their operations that were earlier a hindrance (poor seed quality, lack of visibility, no knowledge of warning system etc) to effectively respond to disasters (Shahzad, Zia, Aslam, Syed, & Bajwa, 2013). This study has found that applying learnt knowledge through forecasting, product improvement and better planning, supply chain members can more quickly respond to disruptions. This quickness, or velocity, is an important

part of agility (Aitken et al., 2002). Unlike other authors who emphasized only the speed aspect of agility (Dove, 2003), this study has found that knowledge utilization increases supply chain flexibility in terms of facilitating change or through supply chain members adopting multiple roles. This role shifting allows these actors to fill 'structural holes' within their network that would otherwise break supply chain flows (Pathak et al., 2014).

In line with the knowledge based view that was developed as an extension of RBV (Acedo, Barroso, & Galan, 2006), these findings also show that knowledge gained through relations/socialization in exchange, contributes substantially to improving the performance of these food supply chains. Furthermore, this analysis shows that knowledge infrastructure capabilities are inherent or inbuilt in these networks. However, KM process capabilities can be seen as related to adaptive and concurrent resilience. Nevertheless, as this research focused on natural disasters, the results are mainly examined from the 'learning' that was derived from disaster management. Hence, learning here is mostly part of the response and recovery phases of the disaster cycle. The following figure (Figure 6.9) illustrates all of the activities and forms of knowledge management and how they are associated to food supply chain resilience.

Figure 6.9 Mapping of KM Activities in Different Dimensions of Supply Chain Resilience



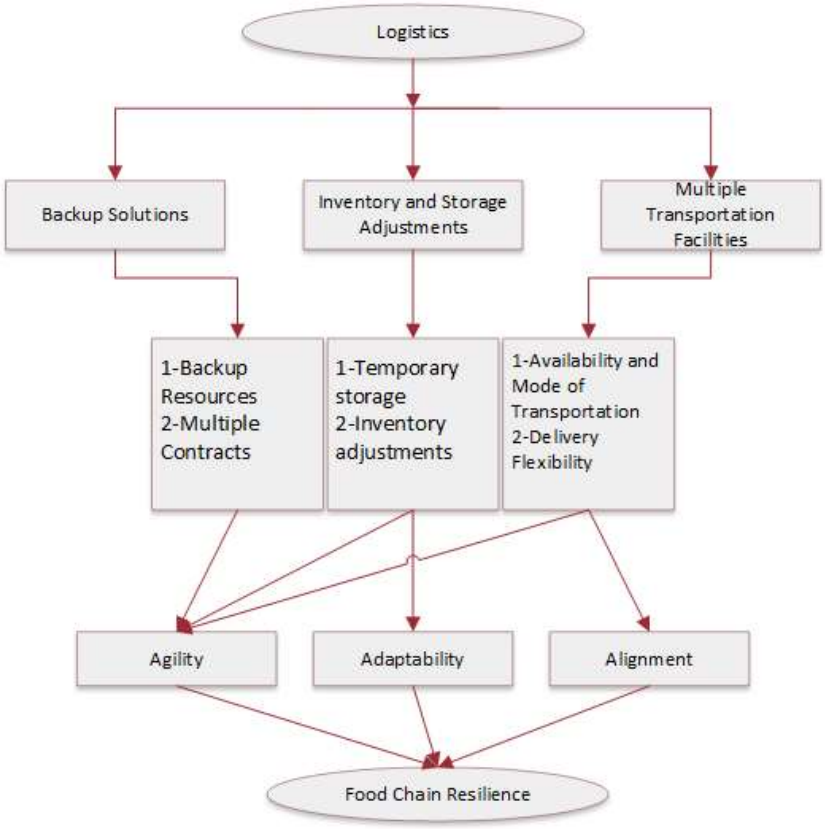
Source: Developed by the Author

6.3 Logistics

Logistics is the third critical area identified by this study's research framework. The underlying activities performed in this area are important in achieving supply chain resilience in natural

disasters (Balcik & Beamon, 2008; Chandes & Paché, 2010; Duran et al., 2013). This research has found that effective backup solutions, inventory and storage adjustments, and multiple transport facilities present in the network enable flexibility, velocity, reliability and the alignment aspect of supply chain resilience. These relationships are presented in Figure 6.10 below.

Figure 6.10 Logistics Activities Leading to Supply Chain Resilience



Source: Developed by the Author

6.3.1 Backup Solutions

Being prepared and organized is essential for dealing with disasters. When disasters strike, and disruptions ensue, backup solutions and contingency planning helps actors to respond and recover from disruptions in a more effective way. This research has found that many actors these supply chains keep a reserve of critical items to cope with disasters. Indeed, there were some instances recorded in the data where actors, utilizing backup solutions, were able to cope with disasters significantly better than non-prepared actors. However, this phenomenon is not common for all the actors these supply chains. The research has identified two major sub-activities in these networks; backup resources and multiple contracts.

6.3.1.1 Backup Resources

If supply chain actors have spare resources or redundancies, they are able to deal with the problems in a more effective manner. However, holding back-up inventory, contingency planning and maintaining redundant capacity can be costly to maintain, especially for food supply chains that have to deal with perishability and a lack of capital resources. Nevertheless, while costly, the most important thing during a disaster is to survive, and cost though important, becomes a temporary secondary objective. As natural disasters can damage physical infrastructure, as well as communication channels, the importance of buffer stocks is crucial. Buffer stocks allow 'flexibility' in these chains in order to respond to local situations. It also obviously facilitates a 'quick response'. These themes were noted by a retailer in C1R1, "…*we keep one week's stock that anything can happen any time so we take care that we don't get in to stock out position... so it is just not about the natural disasters but it is that economy of Pakistan and other circumstances"* (Rt1-C1R1). What is interesting is that this respondent noted the requirement to maintain buffer stocks for disasters and well as normal business operations, hinting at the cogitative merging of the two contexts as 'normal' for these supply chains. The data also shows that keeping buffer stocks is common in all of the chains. While R1 has multiple facilities available throughout the region where stocks can be kept safe, in R2 fewer facilities are available. In terms of scale, it is generally only the large-scale actors in these supply chains who keep buffer stocks, as mentioned by a trader in C2R1, *"…all the good and big actors have their stock ready to deal with these situations"* (Tr1-C2R1). Keeping buffer stock is a built-in quality of these supply chains. The basic reasons offered for keeping these stocks, as noted is not purely as preparation for frequent floods and disasters that afflict these supply chains, but also related to domestic problems within the country, such political instability, strikes, war and other man-made problems. Thus, a quick response and flexibility are important elements of supply chain resilience. These are facilitated by reserve holdings or safety stock. However, this strategy seems to be adopted only by larger actors in these networks.

The findings also suggest that keeping a backup of emergency equipment also facilitates a quick response to disasters. Through learning from previous events, some supply chain actors have started this important activity, as a processor in C2R1 explains, "…*once or twice lightning struck our farm in the rainy season… as you know in first place it affects your transformers so we now have back up generation. We have two stand-by generators for that purpose... we also*

have emergency tools stores so that if we can't go to market to buy them so we must have them for the replacement" (Pr1-C2R1). A number of other instances were also mentioned by different supply chain actors, for example keeping a stock of spare batteries to deal with electricity shortage arising from infrastructure damage. It seems that these behaviours were more prevalent in those members who have better access to the latest knowledge and information. In R2, where the literacy rate is very low and also due to a lack of awareness, the level of these sorts of activities was hardly noticeable. In R2, especially during earthquakes, the local people who worked in the fields, lost their houses and had to move away. The flow-on-effect was that there was a critical shortage of available farm labor. Further, the findings also show that those farmers who had previously built strong relationships with labor providers in other areas (as a backup) were able to respond to this situation quickly and suffered less crop loss. Transportation plays a vital role to keep these supply chains running during difficult times, hence, the next section provides valuable insight into the transport operations of these supply chain.

6.3.1.2 Multiple Contracts

This research has highlighted the importance of having multiple contracts with different transport providers, as one way to respond quickly to disruptions. As one C1R1 commission agent said, "*We have contracts, they send us the vehicle according to our demand and we have number of transport companies to handle these situations"* (CA2-C1R1). In emergency situations, these multiple contracts provide the necessary flexibility and facilitates velocity. If one company is unable to provide transport, then they have the option to switch to another provider. When these transport companies were asked how they fulfil the demand for vehicles, they responded saying that often they maintain backup vehicles. If one vehicle gets stranded on a damaged bridge or road then they can send the backup vehicle to handle the situation, thus they possess a redundancy of assets.

The transport companies who are active within these food chains have wider connections with multiple organizations across different industries. During natural disasters, if they cannot get business from these food chains, then they have the options to switch to other organizations that are not affected by the disruptions, as mentioned by this actor, *"… our truck company has multiple contacts, if they are not providing services to this particular market then they start doing business with diverse range of products"* (LP1-C1R2). This flexibility helps these transport providers stay in business and keep running even in disruptions.

However, the data highlighted many problems with these transport companies. The vehicles were often not fit for roads, and all of the routing tasks, despatching and general handling of these fleets is done in a disorganized manner. Many drivers are not fully trained to handle and maintain their vehicles, to deal with the emergency situations or the changing road conditions during disasters. More problems were observed in R2, as the routes are often narrow, torturous and the infrastructure is of poor quality. However, during emergencies the effective role of relief providing agencies provided a cushion to these supply chains to respond and recover quickly. In R1, especially in the case of the staple food chain, transportation companies are larger scale and more organized. They also have more modern trucks. It has been noted that well planned and organized transportation is necessary for supply chain resilience and these chains can increase resilience by focusing on this aspect of their supply chain.

6.3.2 Inventory and Storage Adjustments

The data indicates that inventory and storage related adjustments before, during and after disruptions help supply chain actors to align their interests. Also, these activities enable flexibility and velocity which directly increases supply chain resilience.

6.3.2.1 Inventory Adjustments

Stockouts are a typical problem, especially when there is a large range of products present in a supply chain. This becomes a much larger problem during emergencies as stockouts can lead to the loss of valuable customers, as well as costing a business a large amount of money. More critical still is the fact that these supply chains provide basic necessities for life. Hence, any significant disruptions could result in a potential loss of life, or certainly, the substitution with relief supplies. This research has found that these supply chains, especially at hub (wholesale markets) and retail levels, use emergency replenishment to avoid stockouts. Normal lead times are longer, but in these situations lead times can be shortened considerably. As one respondent in R1 recollected, *"whenever there is a disaster... every disaster brings hamper orders from relief providers to us that is huge quantity... there when we tell the supplier there is disaster and now your hamper of so and so worth will be sold in ten days. They deploy extra resources to fulfil our order"* (Rt1-C1R1). A quick response by allocating additional resources, such as labour and transportation, can materially help supply chain actors in disasters and shorten lead times. Early warnings, information sharing and collaboration across supply chain

partners also plays key roles in enabling inventory to be reallocated and moved to the point of need quickly.

One of the important finding in this section is product grading. This can be viewed as a built-in quality of these systems, particularly in chains C1R1 and C1R2. Food products of different quality grades will all find different channels to the market. The markets are capable of accepting all quality of grades, and this characteristic provides a flexibility of response, especially when goods are downgraded due to flooding events. This provides a good example of alignment among the inter-organisational processes of these supply chain actors. It has been found that products are graded based on location, quality and size. For example, this commission agent explained, "…*products are categorized based on the location, quality and size, the products which are not good they are sold separately"* (CA2-C1R1). Knowledge acquired through experience helps actors to conduct grading. Firstly, grading is done at the wholesale level while packing the items, as noted by this commission agent, "…*we have middleman, they do the product grading when the items reach this market, as we share information with each other so our suppliers know what is the demand of an item, they only bring that item to the floor and rest of them goes to the storage"* (CA3-C1R2). One more important thing to note here is that standardized packaging is used throughout these supply chains, as revealed by CA2-C1R2, CA1-C1R1 and Fr2-C1R2. Further grading is done at the supermarket level. If some items are not ripe enough, they are taken to storage facilities. Further, those items that are not of good quality are distributed through a separate channel to small handcart operators. Whenever there is a disaster (such as a flood or problems due to earthquakes), food quality is often compromised. However, quality grading and distribution through different channels, provides flexibility to adjust to the situation. Unfortunately, quality food items also degrade over time and with handling, so the challenge for those channels dealing with the lower grades is to cope with an influx of damaged or poorer quality goods. However, this flexibility and alignment of interests enable these chains to cope with disruptions arising from natural disasters, thus making them more resilient.

6.3.2.2 Temporary Storage

In general, there is ample storage areas available alongside all wholesale markets visited. The storage houses are privately owned, often by supply chain actors such as commission agents. These storage areas provide a temporary facility for items that arrive early, or which need time to ripen further, or if there is no current demand for the product due to unforeseen

events. They often operate as a contract warehouse arrangement, as mentioned by a commission agent in C2R1, *"Almost every trader (commission agent) has sufficient space in the market to store produce for a few days (free of cost) or for longer periods for a nominal charge"* (CA2-C2R1*).* A similar situation also exists in CA1-C1R1, CA2-C1R1, and CA3-C1R2. At the farmers' level, there is usually not enough storage spaces available, hence they are also dependant on these market storage spaces. These shared storage facilities thus provide the flexibility to respond to a crisis.

The data also shows some instances where buyers have also stored the items at the supplier's site. The sharing of information plays an important role here. Buyers have bought the items, but due to forecasted floods were unable to transport the items. They share this forecasted information with the supplier and ask the supplier to hold the items for some time. As in this example, *"…like when there was flood in Peshawar... then best thing was that we had stock with us… it was the first thing that helped us… so whoever suppliers work with us we always ask them to stock of it at their place... so we do not actually get in too much trouble in any situation"* (Rt1-C1R1). This information sharing and helping each other enables these actors to respond to disasters in a better way.

Inventory and storage adjustments has a noteworthy effect on the performance of these food supply chains, as well as providing a degree of resilience that the data shows is critical. Nevertheless, current storage facilities are still adequate, not only in terms of size, the number of them and their locations. Additionally, only a small number of actors can take the advantage of these facilities. This also depends on the degree of understanding and trust among these actors. Wherever actors have made adjustments in inventory management or storage management, they have demonstrated greater degrees of resilience as compared to other actors in the network.

6.3.3 Multiple Transportation Facilities

In addition to storage and inventory adjustments, another significant contributor to supply chain flexibility and velocity is the presence of multiple transportation facilities in these networks. It includes multiple modes of transportation as well as a reasonable abundance of available transportation.

6.3.3.1 Availability and Mode of Transportation

Transportation is a key component of any supply chain. Its value becomes even more important during natural disasters. Many respondents stated that one of the reasons why they survived difficult situations was an abundance of available transportation. This is a unique situation in these regions, as compared to other countries, where more formal transport companies operate. Most of the time contractors own their transport fleets, but some of the supply chains actors also invest in their own vehicles. Due to an abundance of options, whenever there was urgency or pressure from buyers or suppliers regarding product delivery, they generally did not face any problems with vehicle availability. As one provider explained, "…*yes, we have contracts, they send us the vehicle according to our demand and we have number of transport companies to handle these situations"* (Tr1-C2R1). Similarly, another actor stated that if a buyer has transport, they also share it with their suppliers. This flexibility and collaboration is a key part of effective response and recovery from natural disaster. As one respondent noted, *"…it is the duty of supplier to manage everything. But sometimes in case of emergency we send our own transport to collect. If someone is dealing directly with farmer then 99 percent it is your duty to arrange transports"* (CA2-C1R2).

Many of the respondents from all of the four chains stated that they outsource the transportation function of logistics to only those third parties who have expertise in logistics. Another important insight was that there are alternative modes of transportation available in these regions. Alternative forms include, small boats, donkey carts and hand carts. As one actor explained, "…*rest of that area there is river... all the bridges were gone... they made a small boat in the river. They took the stock from gardens to road and then to bring it from one bank of the river to the other. It used to be really expensive that nothing was saved to them"* (CA3-C1R2). The last sentence describes how utilizing these means can be expensive, resulting in the erosion of profit margins. Yet, in disasters survival is more important than profit.

6.3.3.2 Delivery Flexibility

Additionally, this study has found that supply chain actors are somewhat flexible in terms of deliveries, even in their normal business operations. For example, as stated by this broker, "*they tell us the demand like if you have raw form of rice then keep on sending us. We have a target of two hundred thousand sacks... either complete it in 10 days or 15 days, we are comfortable with the late delivery but it should be quality rice"* (Br1-C2R1). Concessions are

often made for the transport companies who have to contend with damaged infrastructure during periods of disasters.

Transport companies also use alternative routes in emergencies. But these alternative routes generally involve much longer distances. These delays can mean that fresh produce goes to waste. However, this flexibility of choosing multiple routes still saves much of the products from rotting completely. The conflicts arising from these issues are handled by the conflict resolution committees (Jirga), especially in R2. All of these measures help supply chain members to cope with and adapt to disasters.

6.3.4 Discussion on Logitsics

Logistics play a key role in overall supply chain resilience during the disaster management life cycle (Ponomarov & Holcomb, 2009). Transportation, storage and inventory management are critical areas of logistics that need to be fine-tuned in order to quickly and efficiently respond to natural disasters (Beamon & Kotleba, 2006; Dani & Deep, 2010; Davidson, 2006; Roy et al., 2012). In the disaster management literature logistics is mostly discussed in terms of humanitarian relief supply chains (Akhtar et al., 2012; Duran et al., 2013), but commercial food chains also act in a similar manner, in terms of quick response, survival and regaining normal operations post-disaster.

This analysis has found significant evidence that speed, flexibility and alignment of interest among different supply chain actors are critical elements of logistics, thus contributing towards resilient supply chains. Researchers have foregrounded these elements in the disaster management discipline (Day et al., 2012; Duran et al., 2013; Kovács & Spens, 2007). During disasters (earthquakes and floods), these supply chains operate in some very special circumstances with destabilized processes and compromised infrastructure. In this analysis, damaged roads, poor telecommunication network coverage, unpredictable demands and increasing fuel prices are some of the vulnerabilities in both regions during natural disasters. Kovács and Spens (2007) call these vulnerabilities the characteristics of humanitarian relief logistics. This research argues, but also adds that these can also be considered as characteristics of normal business logistics operations, but are more pronounced during natural disasters.

In the disaster management literature, logistics is frequently mentioned in terms of providing a quick response to disasters (Dubey & Gunasekaran, 2016). In relation to resilience, velocity refers to a quick response to disruptions (Jüttner & Maklan, 2011), and many authors have mentioned that agility can be achieved by responding quickly to situations (Baramichai, Zimmers Jr, & Marangos, 2007; Gligor & Holcomb, 2012). As mentioned earlier, velocity is an important element of agility in relief supply chains, and this velocity can be achieved by prepositioning critical supplies at key points (Bemley et al., 2013). The data shows evidence of this within all of the four food supply chains where a good number of actors keep backup supplies of important equipment such as generators, vehicles and other machinery needed to respond to disruptions. This is true also for prepositioning and building safety stocks of inventory. There were a few instances, especially in the Punjab region, where products were stored in temporary storage areas in order to deal with vulnerabilities originating from natural disasters. Although this phenomenon is not widespread in these supply chains, it can contribute significantly to the response and recovery phases of disasters.

Multiple contracts with multiple transport providers also provides flexibility to respond quickly to disruptions. While switching provides flexibility, this analysis highlights the importance of special long-term contracts with transport companies as a better way to provide a quick response. Although long-term contracts have less flexibility, they tend to be more reliable and enable these actors to quickly respond to disruptions, leveraging trust and commitment built over time. Writing specifically about relief supply chains, Charles, Lauras, and Van Wassenhove (2010) also emphasise the importance of long-term contracts between supply chain actors. Similar special contracts are seen among the well-established members of these supply chains as well. Indeed, transactional outsourcing is often the norm for transportation requirements in both regions as it is seen as a commodity service. There are plenty of available transport resources generally clustered around the main markets, and a number of different modes suited to the local area conditions. The multiple transport resources and multi-modal operations in this study facilitate flexibility and velocity in these networks (Benini, Conley, Dittemore, & Waksman, 2009). In addition, possessing knowledge of the local area and transportation needs are other facilitators of flexibility and velocity. This finding supports Kovács and Spens (2011) assertion that local area knowledge is essential when responding to disasters.

One of the advantages of having multiple transportation options is emergency replenishment. When there is a sudden demand, emergency orders are placed with shorter lead-times. Indeed, the analysis shows that extensive use of emergency replenishment is present in these supply networks, especially within the fresh produce chains. Emergency replenishment is especially associated with those supply chains where emergency transport costs are not very high, while shortage costs in the market are very high (Tagaras & Vlachos, 2001). Therefore, organizations prefer to use emergency replenishment in order to have a continuous availability of products for their customers. However, in these four food supply chains, transportation costs increase significantly during disasters. Yet, the multiple alternatives present in both of these regions compensate somewhat for this problem. This analysis has also revealed that storage costs are very high in these chains which results in the loss of valuable customers.

Furthermore, inventory management is necessary to minimize the overall negative effects of disruptions. Even efficient transportation is dependent on good inventory management practices. Inventory management is also highlighted as a critical function by many researchers in the disaster management discipline (Balcik & Beamon, 2008; Davis, Samanlioglu, Qu, & Root, 2013). This research has found that all of the four food supply chains have mechanisms for product grading, based on the area and quality of the products. These supply chain actors also use standardized packaging that facilitates the quick handling of these items (Kovács & Spens, 2011; Sohrabpour, Hellström, & Jahre, 2012). By dividing products into different quality categories, supply chain actors can achieve flexibility as lower grade products are sold into different channels. This flexibility saves time, energy and allows at least a discounted return for low quality or damaged products. Packaging and grading commences at the farmer level where specifications are shared by other actors in the supply chain. The alignment of these processes contributes towards the resilience of these supply networks.

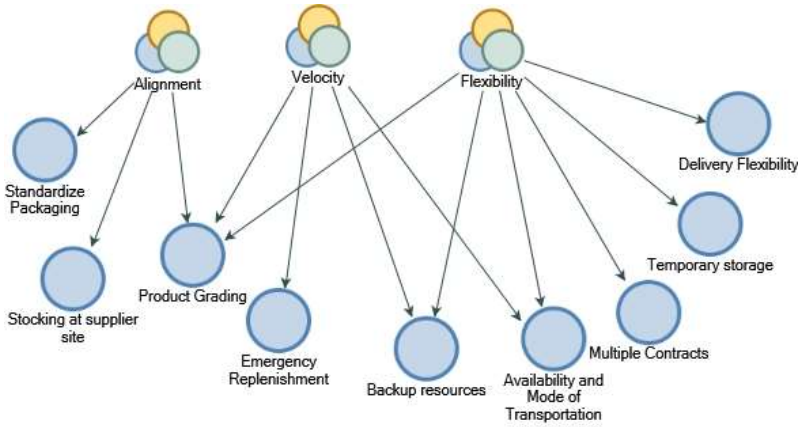
In addition to inventory and transport management, storage also plays a critical role in these supply chains. All of the wholesale markets are well placed, with storage provided at key strategic positions in these markets. Although these storage places are often used for personal purposes rather than to facilitate product flow, the actors who manage them have shown greater resilience than other actors. A key problem is that there are few storage facilities at the farmer level. As a result, they are largely dependent on other supply chain actors. These storage areas help accommodate redundant stock/safety stock holdings and also provide a

temporary cushion if the products are not ripe enough because of severe weather conditions. During times of severe shortages, these storage areas can be used to meet customer demand and provide a temporary buffer for the overall network.

Most of these logistics resources are network based, such as storage, transportation, infrastructure and human resources. The relational view extends the resource-based view by arguing that critical resources span the single firm boundary. Organizations develop capabilities by utilizing network resources (Wills-Johnson, 2008). The same was found in this research as through inter firm relationships, supply chains utilized these resources to respond to natural disasters.

Additionally, many of these activities are part of the inherent resilience within these supply networks. These inherent capabilities are built into the system and contribute to better responses and adaptations to disruptions arising from natural disasters. For example, product grading, availability and mode of transportation are all built in, or extant properties of these chains. When disasters strike, these inherent capabilities are leveraged in order to respond as best as they can, and hence they prove to be remarkably resilient supply chains.

Figure 6.11 Association of Logistics Activities with Supply Chain Resilience Elements



Source: Developed by the Author

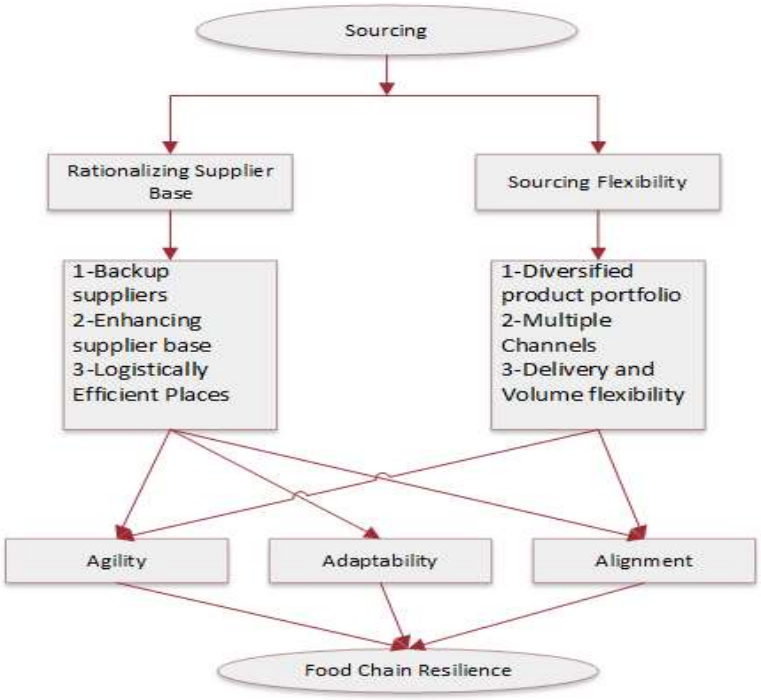
Other than inherent capabilities, all activities present in the backup resources category such as backup emergency equipment, buffer stocks and reserve labor force are part of what can be termed as proactive resilience. In other words, these are deliberate actions designed to prepare specifically for disasters. Through learning from previous events and utilizing knowledge to anticipate needs in advance of a disaster, or merely being prepared for any

disruption, these supply chains have achieved a level of proactive resilience. Overall, the data shows that both inherent and proactive logistics resilience are synergistic, and both materially contribute to the effective response resilience of these networks. Figure 6.11 shows the association of all the logistics activities discussed above, with the main supply chain resilience components.

6.4 Sourcing

Sourcing has been identified as the fourth and final element of effective disaster management (Abe & Ye, 2013; Davis et al., 2013; Handfield et al., 2007). The underlying activities related to sourcing in these supply networks and their contribution to supply chain resilience is discussed below. This research has found that rationalizing their supplier base through implementing backup suppliers, sourcing from logistically efficient places, and widening and enhancing the supplier base can all contribute towards enabling agility, adaptability and alignment. Similarly, having sourcing flexibility through activities such as delivery and volume flexibility, a diversified sourcing product portfolio and multiple channels, can also contribute positively to supply chain resilience.

Figure 6.12 Sourcing Activities Leading to Supply Chain Resilience



Source: Developed by the Author

6.4.1 Rationalizing Supplier Base

This research highlights the importance of rationalizing the supplier base by having backup suppliers in place, by enhancing the supplier base through supplier development efforts and by sourcing products from logistically efficient places. It has been found that these activities contribute positively towards supply chain resilience.

6.4.1.1 Backup Suppliers

Almost all supply chain actors present in the wholesale markets in both regions have multiple suppliers, however a few of them, especially those who are financially strong, maintain backup suppliers as well. These backup suppliers are not their regular suppliers. These actors occasionally source from these backup suppliers for the express purpose of maintaining the relationship. The obvious benefit is that during an emergency, when there is no alternative available, they can source goods from these suppliers. As one actor noted, "*…yes they have other people in backup with whom they deal on and off... like they came to know that Ramadan is approaching and demand will be more... from whom they take… he failed to meet their demand for supply... therefore they will go to other supplier... they will keep relation with them... but they have one or two who are their main source"* (Rt1-C2R1). This flexibility of having multiple sourcing options enables actors meet uncertain demand in the market even due to natural disasters, thus enabling resilience.

Supply chains in these regions, generally have backup sources. The fresh food chains typically use their backup suppliers more frequently, as these chains are more vulnerable to natural disasters. As noted earlier, there are many problems related to poor storage, quality, poor handling of products and perishability. These could be the reason why these actors keep backup sources. As one respondent revealed, "*I don't depend on one supplier in one time. There are ample of feed mills in closed vicinity. There are 3 to 4 large mills in our city. There are more in close cities, so we have developed lines over the industry like first line, second line, and third line suppliers. If I am taking from my mill does not mean I never talk to others. Every month I take two cars from them as well just to maintain a relationship. At times my mill is closed then we have a second line of supply. We have all the contacts. We have proper contracts with procurement managers of the other mills and time to time we operate them as well"* (Pr1-C2R1). However, there were also many actors in the market who had no backup suppliers. The data showed that these firms struggled to bounce back from disruptions and

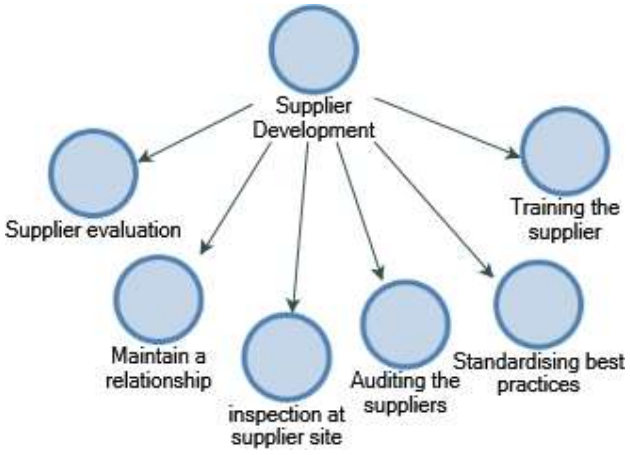
suffered losses during and after disasters. Fortunately, network collaboration helped them to survive as they acquired their supplies horizontally from other members in the market, or they shifted their business to another complimentary domain.

6.4.1.2 Enhancing Supplier Base

In addition to backup suppliers, another related practice was to enhance the supplier base. This is necessary for efficiency and to be prepared for the next event. One of the key reasons why these supply networks survive the adverse effects of natural disasters is that they have a wide supplier base spread across the provinces. Further, the supplier's capability and capacity are enhanced in this wide base through active supplier development.

The most significant finding in this category is supplier development. There are many instances where actors of these chains are actively involved in developing their suppliers. These actors were more resilient compared to the other members, and thus contributed significantly towards the overall resilience of these supply networks. These supply development activities were mostly seen in C1R1, C2R1 and C1R2, while being virtually absent in C2R2. Supplier development helps to align processes and increase the visibility of these chains. It also increases the overall reliability of these chains. Figure 6.13 presents some of the main elements of supplier development activity.

Figure 6.13 Main Elements of Supplier Development Activity



Source: Developed by the Author

Supplier development is done through training suppliers, inspecting products at the supplier's site, supplier evaluations based on financial strength and quality, auditing the suppliers and standardizing best practices. Visibility, alignment and reliability gained through these

measures can enhance overall supply chain resilience, as actors with a well-developed supplier base, are in a much better position to respond to disasters.

6.4.1.3 Logistically Efficient Places

Sourcing or selecting suppliers from logistically efficient places also plays an important role in gaining the required velocity in difficult times. Many of the actors from local wholesale markets procure items from close proximity and strategic locations. This reduces cost and traveling distances. As one respondent shared, *"…due to the floods and non-availability of infrastructure, the industry has started to develop in the surroundings of the cities. Vicinity of R1 has many farms at industrial levels with modern technological facilities. Similarly, there are very few in North side of this city as there is not much space there. Then if you go to northern areas there are even lesser hence when you go upwards from R1, then rates get higher. Similarly, when you move towards southern Punjab and Karachi then rates again get higher. So, this industry is clustered mostly in central part of R1 due to favourable weather conditions, agri-feed, fodder and population"* (Pr1-C2R1). Sometimes these actors had to bear extra costs to procure from a close proximity, but they still preferred close proximity over other more distant suppliers due to the time and difficulties with evaluating those suppliers. Close proximity is possible only in R1, as actors in R2 are spread further apart, thus there are greater distances between actors from the same supply chain. In R1, all of the major wholesale markets are also strategically located and are much closer to agricultural areas. They are therefore easily accessible by the suppliers.

6.4.2 Sourcing Flexibility

Sourcing flexibility is another major component that positively contributes to overall supply chain resilience, through the components of flexibility, adaptability and velocity. Delivery and volume flexibility, diversified product portfolios and multiple channels are key activities found in the sourcing flexibility category.

6.4.2.1 Delivery and Volume Flexibility

Due to the common understanding of the vulnerabilities associated with natural disasters (as mentioned earlier), these supply chain members have a greater flexibility in terms of delivery dates and volume expectations. As one actor stated, "…*in normal circumstances if a supplier could not deliver us on time, then we gave them grace period, otherwise we impose penalties*

as well. If they continuously do this then we switch to other suppliers, however in case of disruptions where road infrastructure is damaged, we are flexible regarding lead times and volume" (Rt2-C1R1). A number of other members, such as CA1-C2R2, MM1-C1R1, CA3-C1R2, also mentioned that they are very flexible in terms of delivery dates, especially during difficult times when infrastructure is damaged. This flexibility is essential in dealing with changing situations. There are other elements associated with this, such as redundancy stock that can be utilized, and sourcing from logistically efficient places that also act as a cushion in these situations.

6.4.2.2 Diversified Product Portfolio

Furthermore, this study has found that a diversified product portfolio encourages flexibility and adaptability, especially in the fresh produce chains of both regions. Most of the members in the wholesale markets deal in more than one product. Indeed, even the farmers harvest more than one product or harvest per year. If one crop is adversely affected because of floods or some other natural disaster, then they compensate by utilizing another crop. As one farmer explained, *"…we don't deal in one item... we deal in all vegetables... if carrots are ruined then we will have turnip, radish, spinach, this is how all vegetables come as a mixture"* (Fr1-C1R1). This situation is particularly important for floods that usually come in one specific season. If vegetables of that season have not done well financially, then other products from different seasons will compensate for that product. It is this multi-product portfolio that keeps these actors in business. Although this is a built-in ability of these networks, and is typical of normal operations, it contributes significantly during a crisis and enables them to respond in a more effective way.

Having a diversified product portfolio also enhances adaptability in these chains, as switching between different products/businesses is easily achieved. As one respondent explains, the network supports this practice, *"If one crop is destroyed in disaster then we do have some knowledge of other products therefore we start procuring that and run our business"* (CA1-C2R1). Although, this switching depends on having good knowledge of different products and also how quickly the concerned members process the information into meaningful knowledge. Collaboration with other members also facilitates this process of switching between different products/businesses. In sum, a diversified product portfolio contributes in a positive way to overall supply chain resilience.

6.4.2.3 Multiple Channels

Sourcing from multiple channels is a key activity that enables these supply networks to cope and adapt to natural disasters in an effective way. This study has found that many of the members of wholesale markets have multiple suppliers, in multiple regions. One wholesalers shared this information, *"…this is what I am telling you... if flood is in one or 2 divisions... This region has 8 or 9 divisions... if there is no flood in one division then we get things from other divisions and continue our business"* (WS3-C1R1). These multiple suppliers provide flexibility, to keep produce flowing if one supplier has limited capacity due to a disruption.

Further, many of these members have also developed a number of key suppliers for critical business items. Although it reduces flexibility to a degree (due to lock-in), the data shows that these chain actors are more efficient in terms of responding to disruptions as compared to members who merely depend on multiple suppliers. Overall, sourcing flexibility has been shown to improve velocity, flexibility and adaptability that in turn increase supply chain resilience.

6.4.3 Discussion on Sourcing

Sourcing has been highlighted as an important function within supply chains. It is responsible for increasing competitiveness within a disrupted environment due to natural disasters (Lawson, Cousins, Handfield, & Petersen, 2009). Indeed, the role of the sourcing for effective disaster management has been highlighted by a number of authors in the humanitarian relief supply chain context (Ertem et al., 2010; Singh-Peterson & Lawrence, 2014). Local sourcing, multiple suppliers and a narrower supplier base are some of the strategies proposed by these authors in order to prepare and quickly respond to disasters.

Developing flexibility in supply chains is a fundamental strategy used to increase supply chain resilience (Pettit et al., 2010). As such, sourcing flexibility is crucial for the continuation of businesses during and after disruptions (Chiang, Kocabasoglu-Hillmer, & Suresh, 2012; Zhaohui Zeng, 2000). Through inter-organizational relationships and collaboration, supply chain members achieve this flexibility in order to maintain supplier availability in times of crisis. This study shows that actors do not rely on single sourcing as it can be a major risk if that supplier loses capacity (Christopher & Lee, 2004). Instead, actors have multiple suppliers who provide critical material to members during times of stress. Indeed, Christopher and Peck

(2004) and Sheffi and Rice Jr (2005) advocate that supply chain members maintain some key suppliers in order to ensure quality and the reliability of their supply. The findings also replicate those of Simangunsong et al. (2011) who recognise the importance of the right mix of supply sources on increasing supply chain resilience. Thus, enabling a quick and flexible response to disruptions.

While Christopher and Rutherford (2004) state that having a smaller supply base increases agility, this analysis shows that most of the members in the hub actually have a wide supplier base. This is also important in these regions as floods are very frequent. By utilizing their large supplier base, these members can procure the necessary produce from other areas that are not disrupted by the disaster. This is a key aspect of business continuity and resilience. The analysis also draws attention to sourcing from logistically efficient places. Suppliers who are located in close vicinity or other easily accessible places are able to respond quicker than others further away (N. Jain et al., 2016).

Inter-organizational alignment and visibility among supply chain members is required in order to build greater resilience to disruptions (Q. Cao & Dowlatshahi, 2005; Pettit et al., 2010). Supplier development is therefore a crucial activity in order to increase alignment and visibility among supply chain members. The analysis of these supply chains in both regions shows that supplier development is done through training, auditing and inspecting the suppliers. Although there are many irregularities, and most of these activities are informal, yet actors who are involved in these kinds of activities demonstrated greater resilience. Further, these activities increase the visibility and alignment of processes of these supply chain actors, thus increasing overall resilience (Barratt & Oke, 2007; R. Shah, Goldstein, & Ward, 2002). This study has also found that in the supplier selection process, the financial strength of suppliers is critical in these chains. This is because suppliers with poor financial strength cannot stay in the business for very long as pointed by Zsidisin et al. (2000). However, in this research financial strength is judged primarily on the ability to repay debt. In other words, it is not based solely on the amount of money one has, but also on the quality of the future crops, and one's history of trustworthiness in previous transactions.

Another important finding concerns the practice of maintaining backup suppliers. This is different from having multiple active or critical suppliers. Backup suppliers, just like emergency stock, are only kept for emergency situations. This is in line with Sheffi and Rice Jr

(2005) suggestion that keeping backup suppliers helps to achieve quick responses to emergency disruptions. Notwithstanding these sourcing strategies, supply chain actors should manage their inventory wisely. As discussed in the logistics section, these supply chain actors grade their products based on quality and origin. This allows alternative channels to be used efficiently. Also, in regard to distribution, these chains typically possess a wide network with multiple channels. The government also plays an important role here, by sponsoring several small Sunday markets for items that do not sell in the main wholesale markets. When combined, all of these measures help with supply chain flexibility, alignment and adaptability, thereby contributing positively towards overall supply chain resilience.

Just like activities present in collaboration, knowledge management and logistics, many of the activities present in the sourcing area are also inherent in these supply networks. For example, supplier development, a wide supplier base, a diversified product portfolio, maintaining key suppliers and multiple suppliers, constitute extant supply chain practices; in other words, normal operations. Yet, these same activities contribute significantly toward responding and recovering from natural disasters. Additionally, having back-up suppliers and sourcing from logistically efficient places can be considered elements of 'proactive resilience,' while prioritizing products, delivery and volume flexibility can be thought of as 'concurrent resilience.'

The four main sections (Sections 6.1 - 6.4) above have discussed the underlying elements of collaboration, knowledge management, logistics and sourcing that constitute the three main components of supply chain resilience (agility, alignment and adaptability) as identified in the literature. The analysis has revealed how these food chains acquire and use capabilities in order to become more resilient against natural disasters. The following section explains the two main factors that facilitate all of these underlying activities and increase supply chain resilience.

6.5 Facilitating Factors

In the conceptual framework, this study introduced risk management and supply chain orientation as two factors that are said to facilitate supply chain resilience as suggested by a number of authors (Jüttner et al., 2003; Leat & Revoredo-Giha, 2013; Pettit et al., 2010; POPA, 2013). However, the analysis of these four supply chains has shown that basic risk management practices and a supply chain orientation are virtually non-existent in these

chains. On the surface this result is surprising, but less so, when considering the context of these supply chains. These chains are more agrarian and unsophisticated as opposed to their mechanistic industrial supply chain cousins of first-world countries, where sophisticated risk management practices are usually present, even mandated by law. Basic risk management is present but as sophisticated risk management is absent, therefore, risk management is not considered as facilitating factor. Despite the absence of these two contextual factors, the analysis has identified two other capabilities and facilitating factors that contribute to resilience. Indeed, it has been found that supply network structure and social capital are two additional facilitating factors that provide these supply actors with an environment in which to build better supply chain functionality, and hence supply chain resilience.

6.5.1 Network Structure

A network is set of nodes and vertices. Nodes can be thought of as the organizations or individuals conducting business, while vertices can be thought of as the relationships, or flows that exists among the nodes (Pathak et al., 2014). In terms of supply networks, the relationships among the nodes are characterized by flows of information, finance and products (Hearnshaw & Wilson, 2013). All four supply networks of this study can be considered as complex adaptive systems (CAS) (Choi & Wu, 2009), as there are a significant number of nodes and relationships that exist within these networks. The supply chain members or nodes are also of a varied nature (suppliers, buyers, government organizations, relief chain members, armed forces and research institutes as examples). These networks can also be seen as self-organizing, while the whole network operates on individual members' decisions, rather than being directed by a centralized channel leader or node. These decisions are combined in a nonlinear and decentralized (complex) fashion. It is this connectedness that makes these networks appear to behave coherently as a result of the sum of all individual decisions (Pathak et al., 2007; Wycisk, McKelvey, & Hülsmann, 2008).

The literature also notes that another feature of CASs is the presence of organizational learning (Wycisk et al., 2008). The analysis reveals that this also exists among the firms present in these supply chains and has been discussed under knowledge management previously. Similarly, it has been observed that actors present in these supply chains have connections/relationships that facilitate the flow of information. These network connections facilitate the collaboration, reduce opportunistic behavior and enhance resilience (Hearnshaw

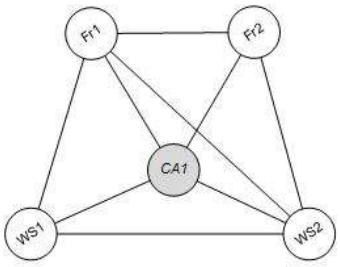
& Wilson, 2013). Another important feature is the absence of a single organization that tries to control the whole supply chain. Nevertheless, there are many organizations/actors in the wholesale market and this wholesale market combined can be considered as the controlling hub of the whole supply chain. Furthermore, while each actor tries to achieve his/her own objectives, they coalesce in order to respond and recover to any disaster, thus contributing to collaboration and collective behavior (Day et al., 2012). Why each actor tries to achieve his/her own objectives in normal conditions, the answer is that they do not have the in-depth knowledge and orientation of supply chains. Yet, when there is a difficult time they invariably help each other. Nevertheless, when viewing these supply chains using a micro lens, there are clear examples of power asymmetry, and these often exist between commission agents and farmers, with commission agents possessing most of the control and leverage.

Similar to other social and business networks, these networks have also shown some elements of three universal properties of efficient networks. It would be worth mentioning here that this research has not directly measured these properties using network formulae, rather, these networks only *appear* to possess these properties. These properties are; small world, high clustering coefficient and power law distribution (Albert et al., 2000; Barabási, 2009). The first, small world properties, is defined as the shortest path length between any two randomly selected two supply chain members (nodes) in the supply network. A short characteristic path length means a small number of traverses are needed to connect two random nodes in the network. In these supply chains, the presence of the large central wholesale markets and the long-distance links (that is, those between these markets and farmers directly and other ancillary actors) provide the mechanism for distant actors to connect to the network. These long-distance links, or a small world, contributes significantly towards information flows and collaboration in the whole supply chain.

Secondly, a clustering coefficient within the network is the probability of any of the immediate nodes being connected to each other in a triadic relationship (Hearnshaw & Wilson, 2013). If many of the immediate first tier nodes are connected to each other, then a high clustering coefficient is present. These triadic relationships affect the dyadic exchanged between two members in the supply chain (Choi & Wu, 2009). If the coefficient is high and members are connected at vertical, as well as horizontal levels, this facilitates the flow of information and mitigates opportunistic behavior in supply chains. This study has observed a very high clustering coefficient of approximately 0.83 in chain C1R1, where 5 of 6 possible triadic

connections were present in one core structure. As these supply chain actors are closely associated with each other, they possess information of different operations and different supply chain roles in the wholesale markets. This facilitates the switching of roles and access to financial help during emergencies. Flexibility in volume and delivery dates are also aided by these close triadic relationships.

Figure 6.14 Possible Triadic Combinations in C1R1



5 out of 6 possible triadic combinations.

Source: Developed by the Author

The third important property that is observed in these supply networks is the power law connectivity distribution. While a power law is a quite specific distribution, this research relies on less specific distributions (such as the Poisson) that would approximate distributions where a very small number of nodes possess the greatest number of connections[1]. Given this interpretation, this property appears to be present in three of the four supply networks yet is clearly missing in C2R2. A connectivity distribution is the average number of connections possessed by any one node. In these three supply networks, only one node per supply chain has a high degree of connectivity as compared to all of the other nodes. These nodes, the wholesale markets, can be considered as a hub node as they are connected to almost all of the other actors and peripheral organizations in these supply networks (Albert et al., 2000; Barabási, 2009). These wholesale markets are present at tactically chosen locations (built by the government), where they provide a platform for buyers and suppliers to interact. Commission agents act as the custodians of these markets and many of them are also connected with each other horizontally.

These hubs also possess a governing mechanism that can be described as participatory governance. It appears that network members come together and form a permanent market

[1] Given this lower level of specificity, these networks could not be described as 'scale-free' networks.

committee that facilitates the process of decision making in these markets. This is also the same platform for general conflict resolution (the Jirga) between different supply chain actors (Provan & Kenis, 2008). These wholesale markets control performance and provide network wide coordination (Cowan & Jonard, 2007). They also provide financial support to supply chain actors and also facilitate the process of information dissemination, knowledge management and collaboration within the whole network.

Literature has described a single firm with a high number of connections as a hub firm and pointed to examples such as Wallmart, Toyota and some of the major pharmaceutical companies (Barabási, 2009; J. Wang, De Wilde, & Wang, 2009). However, by looking at the definition of hubs as a "…place of concentrated activity, influence or importance" (Roget's Thesaurus), it is possible that the meaning of a 'hub' can be wider than a single firm. In addition, there are also a number of research papers on the effectiveness and emergence of food hubs, a local place where farmers and suppliers can directly sell fresh produce to consumers (Blay-Palmer, Landman, Knezevic, & Hayhurst, 2013; Matson, Sullins, & Cook, 2013). Hearnshaw and Wilson (2013) have also pointed our attention to this by introducing a network property called the 'community structure'. They contend that community within the supply chains is a group of organizations with similar interests and those are connected mainly by horizontal connections. This study agrees and points to the wholesale markets that are present in three out of the four cases that act like communities where groups of different actors are present for the same purpose. These 'hubs' are actually clusters of organizations co-located, with everyone having different, but overlapping networks of buyers and suppliers. This proximity facilitates the exchange of information and tight coordination. All of these independently owned businesses are governed by the same governing body. Therefore, the data suggests that these wholesale market can be considered as acting as a single hub that possesses the largest number of connections in the supply network. As such, this structure of supply networks with the presence of hub markets, facilitates the core processes of knowledge management, collaboration, logistics and sourcing and ultimately builds resilience in these supply chains (Hearnshaw & Wilson, 2013; Sheffi & Rice Jr, 2005; Watts & Strogatz, 1998).

6.5.2 Social Capital

Closely linked to social networks, this study has observed that social capital is another facilitating factor that plays an important role in supporting all of the activities present in the four areas discussed. The presence of good levels of mutual trust and collaboration helps these actors achieve a common objective of facing, surviving and adapting to natural disasters (Dynes, 2002).

It has been observed that natural disasters can damage resources such as human/economic/physical capital. However, this study points to the fact that less tangible resources such as social capital are the least affected, rather there is often an enhancement of this capital during difficult times. Social capital plays a critical role in strengthening capabilities at different levels of the supply network and allows a better response to disasters. This is due to the way these networks are structured with the presence of a central hub that provides a platform for suppliers and buyers to interact. As discussed in the literature review, there are three main types of social capital that can be seen in a given context; bonding, bridging and linking (Aldrich, 2011). This study has observed all three forms of social capital in these chains.

Bonding social capital refers to the connection among family members, friends or within the same community or market (Krause et al., 2007; Yli-Renko, Autio, & Sapienza, 2001). Within the wholesale markets, and also within same geographic area, these supply chain actors develop close relationships. This is due to most being family businesses, with many of them being related to each other (or at least from the same clan or family grouping). They typically have higher trust levels as they belong to the same territory. They also share the same cultural narrative of disasters and often see disasters as an act of God. They also develop a common understanding of different events and hence support each other to achieve tasks and survive. There were many examples of cooperation evident among supply chain members in the marketplace or at farmer level where they coordinated tightly within family groups to respond to disruptions. Financial help for each other is also evident in many relationships, and conflict resolution (Jirga) is also facilitated because of the prevalence of social bonding capital where the local community resolves their problems.

Social bonding capital also fosters knowledge management and information sharing as individuals share the same stories and trust each other. Prior experiences with disasters and

social memory are shared through the community. In turn, this helps the community to prepare for the next disaster (G. A. Wilson, 2013). Communities with low bonding social capital generally recover much more slowly from the negative effects of disasters, even if finance is available (Aldrich, 2011). For example, all of the wholesale market members jointly hired an organization to help remove mud from the market after one flood. This example clearly shows how important it is to have close bonding to facilitate collaboration with other supply chain members.

In terms of supply networks, bridging social capital is the social capital that exists between members of the wholesale market and their buyers and suppliers, or vice versa. This bridging capital complements the bonding social capital (Sanyal & Routray, 2016). In this analysis, there are many examples that show how this social capital is developed. For example, actors share the same stories, myths and metaphors that provide strong mechanisms for creating and exchanging learning and knowledge about dealing with disaster amongst these actors. The level of trust present in these actors, achieved through regular interactions, helps them to support each other in difficult times. This bridging social capital helped actors in this study to respond, recover or adapt to disaster better and quicker than others (Dynes, 2002). By maintaining bridging capital, vertical supply chain members find it easy to share knowledge. There is reciprocity present in these bridges as they are dependent on each other. It also helps them to achieve flexibility and adaptability in these chains (Johnson et al., 2013).

Lastly, linking social capital refers to the connections or bonding that occurs with those members of society who possess power or authority within and/or external to these supply networks. Many of the supply chain members have political affiliations with the key national politicians or ministers and they use these links during disruptions. Indeed, on a number of occasions this study has observed the misuse of these links, which has resulted in significant losses to other members of the society. For example, the route of the flood waters in one year was changed to save one big landlord. This decision destroyed many other small farmers. However, most of the time, this linking social capital facilitates the functions of knowledge management, logistics and collaboration. Bonding social capital also helps to increase linking social capital. For example, in all of the four chains, farmers through their bonding social capital came together to seek help from the Government.

From the analysis, it can be inferred that social capital has a positive influence on different activities present in these supply chains. This facilitation by having strong bonds with a certain degree of trust and shared values, can further help to reduce the level of suffering of supply chain members in emergencies. It also helps them to cope and better adapt to situations.

Hence, as a result of this analysis, the hypothesised facilitating factors of risk management and supply chain orientation have not been found. Rather, what emerged from the data were two other closely related facilitating factors of network structure and social capital. This is a new contribution to the study of supply chain resilience.

6.6 Summary

This chapter has presented the findings of this research in detail. Discussions on those findings were also a necessary part of this chapter in order to maintain continuity. It has been found that collaboration, knowledge management, logistics and sourcing all positively contribute towards supply chain resilience. For each of these four areas, the underlying activities that make up each element were also identified and discussed, along with their contribution towards the conceptual elements of supply chain resilience. The expected facilitating factors of risk management and supply chain orientation were not evident in this study. However, the data pointed to two further facilitating factors; network structure and social capital. The chapter discussed their positive contributions towards supply chain resilience. The final chapter provides a succinct conclusion and the contributions of this research.

Chapter 7

Conclusion and Contributions

This chapter presents the conclusions of this research, building on discussions in the previous chapters. The first section provides a summary of the research and concludes the research findings. Next, the main contributions to literature, theory and policy discussions are presented. Finally, the chapter discusses the research limitations, along with suggestions for future research directions.

7.1 Summary

The overall aim of this study was to identify the underlying concepts and activities that contribute towards the resilience of food supply chains exposed to natural disasters, in particular floods and earthquakes. Much of the previous literature and empirical work in the fields of disaster management and supply chain resilience has focused on relief/humanitarian supply chains. However, this study departs somewhat from this focus and considers commercial food supply chains, but in a disaster context as they face similar problems when faced with major disruptions. Few studies have addressed commercial food supply chain resilience (that run parallel to relief food chains), in the face of natural disasters.

The literature review on disaster management and humanitarian relief supply chains revealed that collaboration (Asgary et al., 2012; Jahangiri et al., 2011), knowledge management (Islam & Chik, 2011; Pathirage et al., 2012), logistics (Holguín-Veras et al., 2012; V. Jain et al., 2012; Jensen, 2012; Liberatore et al., 2014), and sourcing (Ertem et al., 2010; Kovács & Spens, 2007) are crucial areas for effective disaster management. Similarly, risk management is not enough in itself to deal with natural disasters that have a high impact and low probability. Rather, resilience is suggested as an effective way to deal with such situations (Sheffi, 2015).

Supply chain resilience is discussed in the literature in a number of different ways. For example, Sheffi and Rice Jr (2005) consider flexibility, redundancy and adaptability to be indicative of supply chain resilience. Others postulate that agility and collaboration are the main components of resilience (Pettit et al., 2010). Derived from the mostly frequently discussed components in literature, this research adopted Lee's (2004) conceptualization of agility, adaptability and alignment as the three main components (Christopher & Peck, 2004;

H. L. Lee, 2004). Further, based on the literature review, this research has categorized resilience into four categories; inherent resilience, proactive resilience, concurrent resilience and adaptive resilience. In terms of the disaster management cycle, inherent and proactive resilience are often associated with the pre-disaster category, while concurrent resilience is related to the response stage and adaptive resilience occurs in both the response and recovery stages. In order to examine the resilience of food supply chains in a developing economy, this study has developed the following research questions:

RQ_1: What are the supply chain capabilities that make food supply chains more resilient to natural disasters in developing economies? Specifically;

a) What are the underlying activities within vertical/horizontal collaboration, knowledge management, logistics and sourcing that contribute to food supply chain resilience?

b) What are the overall facilitating factors that contribute to food supply chain resilience?

c) How do these activities (RQ_1a-b) lead to the higher order supply chain resilience constructs of agility, adaptability and alignment?

To answer these questions, this research then developed a conceptual framework based on the literature on supply chain resilience and disaster management. Using the case study research method, an empirical investigation was conducted to explore these concepts in two different regions of the same country, but both subject to reoccurring natural disasters.

This research found that the underlying activities present in collaboration are the main contributors towards supply chain resilience. These activities are also important for knowledge management, logistics and sourcing to work effectively. Previous research has focused primarily on collaboration as the central component of supply chain resilience. However, this research has focused more on finding the extant underlying activities within collaborative efforts that are associated with supply chain resilience in a developing country context. At the vertical level, the analysis found that effective communication and information sharing is one of the most important components of supply chain collaboration. Relationships between supply chain actors depend on information sharing that is visible across the supply chain (Holweg & Pil, 2008). Particular information (about disruptions or any changes to the supply chain) can be acquired by communicating with other supply chain actors (Ritchie & Brindley, 2007). Information sharing and communication is achieved through the effective use

of telecommunications, site visits and above all, mutual dependency. These activities enable visibility and flexibility in supply chains to respond to difficult situations (Barnett & Pratt, 2000).

Mutual dependence can be considered as one of the main contributions toward communication and information sharing among supply chain members. Mutual dependency equates to interdependent, therefore when dealing with natural disasters, actors coalesce to resolve the situation. Mutual dependence has both negative and positive effects in normal business operations. While it reduces the flexibility of switching to different suppliers and potential buyers, in difficult times it helps the network to respond and recover more quickly and effectively.

One of the main vulnerabilities in the regions studied is the lack of formal financing options or financial institutions, such as second tier lenders that would typically be seen in a free market economy. Although there are multiple banks available, their high costs and complex products are significant barriers to engagement. Thus, local food supply chain organizations (especially small-scale businesses) are reluctant to use their services. This is compensated by the presence of non-institutional financial support (mostly provided by commission agents) available in these regions, especially when the hub is providing the support. This support is a very important contributor to adaptability and also contributes positively towards aligning the interests of supply chain members. This research concludes that chain coordinators (hubs), through their commitment and support to other members, make the supply chain more aligned, agile and adaptive.

In addition to vertical collaboration, competitors at the same horizontal level also share resources and information, supporting each other financially and seeking common solutions. This is known as coopetition (Bengtsson et al., 2010b). Network dynamics encourage organizations to cooperate with their competitors to survive disasters (Gnyawali & Park, 2009). Scholten and Schilder (2015) have stated that collaborative activities between competitors leads to flexibility and velocity in supply networks. A contribution of this research is to show that besides flexibility and velocity, coopetition helps achieve adaptability (through financial support), and supply chain alignment (through sharing information).

This research also confirms that government support in food supply networks is a significant contributing factor for promoting adaptability, velocity and reliability, thus increasing supply

chain resilience. There are of course greater vulnerabilities associated with this activity, such as corruption, poor policies, poor planning and the influence of strong parties. However, if these issues could be resolved, there would be a marked increase in the overall resilience of these chains.

In addition to government support, the interaction between relief chains and food supply chains also helps achieve supply chain resilience through agility and adaptability. This collaboration is a two-way process; relief chains facilitate food chains and vice versa. This study concludes that local procurement, retailer and wholesalers quick demand fulfilment of relief processes, infrastructure restoration by relief providers and awareness programs, make the overall food chain network more flexible and adaptable, which in turn increases resilience.

Finally, building and maintaining trust is essential, because without these, both vertical and horizontal collaboration is impossible. This research finds that building and maintaining trust mostly originates from social norms within these regions, and that high levels of trust helps to achieve agility, adaptability and alignment. Presence of the special conflict resolution process (Jirga and the market committee) provide a high degree of confidence within these chains and ultimately builds trust. Nevertheless, conflict management is an important activity as many conflicts arise during difficult times in these food chains. Yet, due to the incompetent and slow formal judicial system, actors prefer to resolve their issues using the Jirga as the more efficient alternative dispute resolution system. However, this system has also its own flaws, such as decisions influenced by parties who have more financial power, weak decision-making processes and non-acceptance of decision by the parties. The provincial government has recently made moves to provide Jirga's with legal status by establishing dispute resolution committees, but the process is slow. This Jirga system is rather unique in the context of global supply chains, yet understanding the conflict resolution processes and trust building aspects this mechanism, as out lined in this research, is a contribution to the debate on the drivers of supply chain resilience.

Closely related to collaboration, this research has found that food supply chains should be engaged in active knowledge management in order to become more resilient. Knowledge management infrastructure is the building block of effective knowledge management. Specifically, the infrastructure of culture, structure and technology all positively contribute towards achieving adaptability and velocity in food chains. However, this study has found that

network structure plays the most crucial role in facilitating knowledge management processes and helps supply chain members to adapt to disruptions. It seems that when a network structure is cohesive and collaborative, it enables faster knowledge transfers (Reagans & McEvily, 2003).

Although knowledge management is processed in a variety of ways, this research has discerned three distinctive processes at work within these supply networks. These are knowledge management, knowledge sharing and knowledge utilization. Indeed, the boundaries between the three are blurred as these processes often occur simultaneously, especially learning and sharing. Knowledge is acquired through centres of expertise (research institutes, government agencies and other relief providers) and learning. Warning systems, infrastructure improvements, and information about new methods of agriculture acquired through centres of expertise all help supply chain members to build resilience to natural disasters. However, there were many shortcomings recorded in these practices. Often information was not up-to-date, while at other times, there were inconsistencies in the information, that increased vulnerabilities. Lack of awareness (related to these elements), was also a major issue in these supply chains and occurred mostly at the production/farmer level. If the governments in both regions can create more awareness and support initiatives to decrease inconsistencies in the information, it will positively contribute to the overall resilience of these supply chains. Additionally, it is argued that the most important element in disasters is 'learning' (Barnett & Pratt, 2000; Choy, 2006; Lu et al., 2013). While the literature argues that it is a constructive and critical factor in responding to disruptions arising from natural disasters (Kovács & Spens, 2007), this research found no formal learning mechanisms present in these supply chains. Rather, the contribution of this research is that learning stills takes place, but only through actually experiencing the events. As such, learning during these disasters is non-programmed and experiential, but still helps these supply chains in terms of adaptability.

There are two ways by which knowledge is shared in these chains; one is formally through training and guidelines provided to suppliers, laborers and other members. The other includes more informal mechanism of socialization and collaborative interactions, where different parties come together and interact with each other to share knowledge. It is primarily at the wholesale markets where buyers and supplier interact with each other and share their tacit knowledge, a form of tacit-to-tacit knowledge exchange (Bharadwaj et al., 2015). This coming

together, sharing of insights and transferring knowledge increases the absorptive capacity of supply chain members, thus making them more adaptive (Harri Laihonen, 2015). Finally, this study has found that applying learnt knowledge through forecasting, product improvement and better planning, supply chain members can more quickly respond to disruptions. This quickness, or velocity, is an important part of resilience (Aitken et al., 2002).

Supporting the findings of other authors, logistics plays a vital role in overall supply chain resilience during the whole disaster management cycle (Ponomarov & Holcomb, 2009). In particular, transportation, storage and inventory management are the most critical areas of logistics that need to be fine-tuned in order to quickly and efficiently respond to natural disaster (Beamon & Kotleba, 2006; Dani & Deep, 2010; Davidson, 2006; Roy et al., 2012). During natural disasters, logistics is mostly discussed in terms of humanitarian relief supply chains (Akhtar et al., 2012; Duran et al., 2013), but commercial food chains are also similar to these relief chains in terms of quick response, survival and regaining the normal operations after disaster. Indeed, this research confirms that speed, flexibility and alignment of interest among different supply chain members are the most crucial elements of logistics in order to make supply chains more resilient to disasters. The contribution is that, in this context, there is little to distinguish between the logistics activities of humanitarian relief supply chains and the commercial food supply chains in this study.

Multiple contracts with multiple transport providers also provides flexibility to respond quickly to disruptions. While switching provides flexibility, this analysis highlights the importance of special long-term contracts with transport companies as a better way to provide a quick response. Although long-term contracts have less flexibility, they tend to be more reliable and enable these actors to quickly respond to disruptions, leveraging trust and commitment built over time. One of the advantages of having multiple transportation options is emergency replenishment with shorter lead-times. Indeed, the analysis shows that extensive use of emergency replenishment is present in these supply networks, especially within the fresh produce chains.

Inventory management is also highlighted as a critical function by many researchers in the disaster management discipline (Balcik & Beamon, 2008; Davis et al., 2013). This research has found that all of the four food supply chains have mechanisms for product grading, based on the area and quality of the products. These supply chain actors also use standardized

packaging that facilitates the quick handling of these items (Kovács & Spens, 2011; Sohrabpour et al., 2012). By dividing products into different quality categories, supply chain actors can achieve flexibility as lower grade products are sold into different channels. In addition to inventory and transport management, storage also plays a critical role in these supply chains. All of the wholesale markets are well placed, with storage provided at key strategic positions in these markets. A key problem is that there are few storage facilities at the farmer level. As a result, they are largely dependent on other supply chain actors. These storage areas help accommodate redundant stock/safety stock holdings and also provide a critical temporary buffer for supply fluctuations and also supply chain disruptions. However, buffer stock is usually only held for commercial, not specifically resilience reasons.

Additionally, this study concludes that effective sourcing is also critical for supply chain resilience. Sourcing activities such as rationalizing the supplier base through backup suppliers, sourcing from logistically efficient places, widening and enhancing the supplier base, all enable the agility, adaptability and alignment aspects of resilience. Similarly, having sourcing flexibility through activities such as delivery and volume flexibility, diversified sourcing and/or product portfolios and multiple channels also contribute positively to supply chain resilience.

Other than these four major areas, this study highlights the importance of network structure and social capital as being the key facilitating factors for all the activities present in these four areas. This study confirms that networks with large scale wholesale markets (acting as hubs), facilitate collaboration, knowledge management, logistic functions and sourcing decisions. Closely related to social networks, this study confirms that social capital has a positive influence on different activities in the examined supply chains. This facilitation by having strong bonds with high levels of trust and shared values can help reduce supply chain members' levels of suffering in times of emergency. It also helps them cope and adapt to the situation.

As an important contribution to the concept of resilience, this study found that most of the elements and underlying activities documented belong to what can be called inherent resilience. These are actions/operations inbuilt into these food networks for normal business reasons rather than specific proactive actions taken to enhance resilience. As the studied regions have poor infrastructure and generally poor management, these inherent elements of the chains act as a shield against disruptions rising from natural disasters. Yet, these inherent

elements also contribute towards proactive measures, as well as the concurrent and adaptive resilience of these members. An important contribution is that many of the supply chain members of the hub have higher levels of inherent resilience, and this compensates for the low levels of resilience of other, more vulnerable members, thus facilitating the resilience of the entire system.

7.2 Contribution

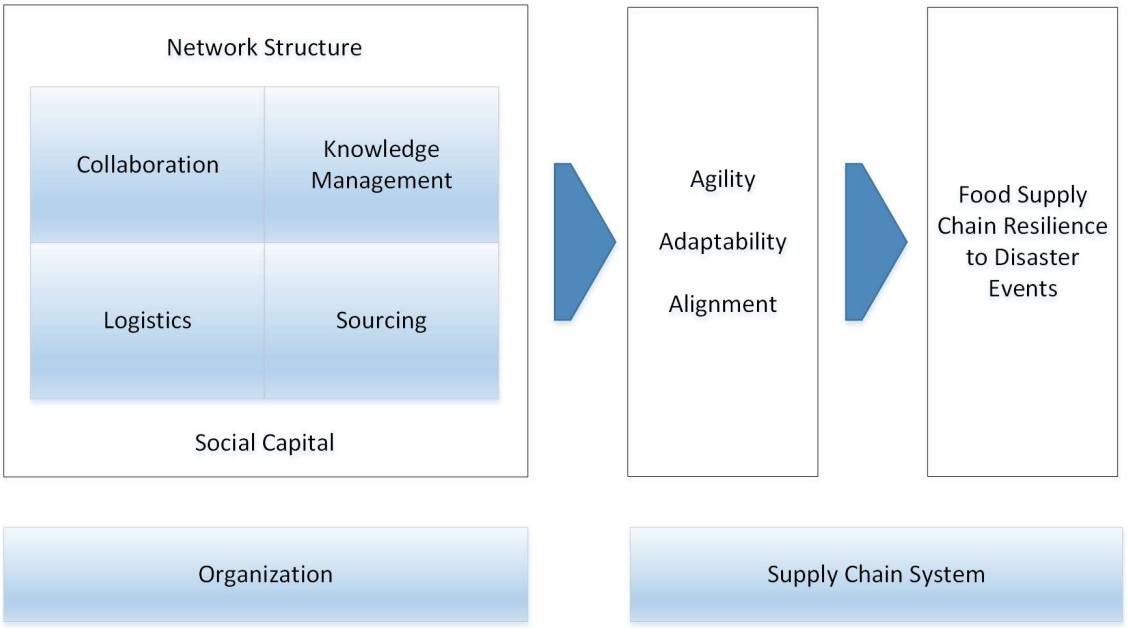
This research contributes both to the literature of supply chain resilience, as well as operational and policy making. It is believed that the following four contributions have been made:

7.2.1 Contributions to the Literature

Firstly, the contribution of this study starts with the development of a conceptual framework that combines elements of disaster management/relief chains and supply chain resilience. This framework presents the four main areas of supply chain management that are crucial in a natural disaster context and associates these with the supply chain resilience components of agility, adaptability and alignment. There are many frameworks related to supply chain resilience in the pre-existing literature (Peck et al., 2003; Pettit et al., 2010; Ponomarov, 2012; Sheffi, 2015). Each of these have contributed significantly in the field of supply chain resilience and were invaluable in the process of constructing the framework for this research. However, there is lack of consistency in identification of supply chain resilience constructs. Especially, the relationship *between* constructs is unclear (Ali et al., 2017; Burnard & Bhamra, 2011; Melnyk, 2014; Ponomarov, 2012). Similarly, in disaster management/relief supply chains literature, there are many areas and components mentioned that need to be managed to effectively deal with the disasters (Kovács & Spens, 2011; Pathirage et al., 2012; Van Wassenhove, 2006). In this research, an extensive literature review on relief supply chains that operate in regions disrupted by natural disasters has identified four crucial areas of supply chain management: collaboration, knowledge management, logistics and sourcing. On the other hand, there have been several supply chain resilience concepts identified in the literature. As such, this research has combined these concepts into three main components: agility, adaptability and alignment, reflecting Lee's (2004) 'triple-A' supply chain, but describing different underlying activities. Similarly, the literature review on supply chain resilience suggested two facilitating factors, these being risk management and supply chain orientation (this research has found network structure and social capital as facilitating

factors). This research then brought all of these fragmented concepts together to create a framework that can be used to study (food) supply chain resilience in developing economies (Figure 7.1).

Figure 7.1 Supply Chain Resilience Framework



Source: Developed by the Author

The second main contribution to the literature is unravelling the specific details of the important activities in the four main supply chain management areas of collaboration, knowledge management, logistics, and sourcing, and connecting these to the supply chain resilience components of agility, alignment, and adaptability. These specific details are particularly important for the regional context that was studied. In the past, most of these details were discussed in the literature, but only in isolation (Dorasamy et al., 2013; Scholten & Schilder, 2015; Van Wassenhove, 2006; Y. Wang et al., 2010). However, this research has attempted to bring these all together and highlight their associations with resilience components. The activities described under collaboration not only contribute to supply chain resilience components, but also influence positively the activities of the other three areas of knowledge management, logistics, and sourcing as well. For example, the knowledge sharing activity (categorized under knowledge management) depends upon the level of collaboration among supply chain actors. Further, previous research has focused primarily on vertical collaboration (Scholten & Schilder, 2015). Yet, interestingly this research has identified

horizontal collaboration as one of the key contributors towards supply chain resilience. For example, collaboration between commercial supply chains and relief supply chains is positively associated with greater overall resilience of the food networks. Similarly, the underlying activities of knowledge management, logistics and sourcing have been revealed in the given context of a developing economy. Further, the association of these activities with supply chain resilience components has been highlighted in this research. In this way, this research adds to the supply chain resilience literature by confirming the importance of the four identified areas of the model. This information may help managers to better coordinate the flow of products and information along the network to survive disasters. Moreover, it appears that the majority of these activities are part of the inherent resilience of these food supply chains. Indeed, only a few of the underlying activities identified can be considered part of proactive resilience. In short, it seems that inherent resilience is a significant factor in food supply chain resilience and is an area that appears to be over looked in literature.

Thirdly, many of the previous studies on supply chain resilience take a dyadic view of supply chains (Choi & Wu, 2009). Very few studies examine supply chains from a network or at least a triadic view (Pathak et al., 2007; Wilhelm, 2011). This research has collected data from four different chains in two different regions. At each tier of the supply chain, data was collected from at least two actors. Therefore, the findings of this research go beyond a simple dyadic view, demonstrating that supply chain resilience is influenced by the underlying activities of collaboration, knowledge management, logistics and sourcing at a network level as well as firm level. Adding to this network level view, this research has provided a different perspective (multi-node groupings that act as a singular coordinating hub) with which to examine the phenomena of hub firms in networks. As discussed in the network theory section on scale-free networks, individual nodes that have the highest number of connections (a Power law distribution) are considered to be hub firms (Barabási, 2009). However, in this research it appears that the wholesale food markets present in three of the four chains have multiple actors and the greatest number of connections overall and act as hub nodes. This is in spite of the fact that these are multi-node groupings that act as a singular coordinating hub. This small community of many firms appears to be behaving in a similar way to hub firms, by controlling and facilitating other supply chain members, disseminating information, finance and setting channel policies, especially in times of disasters.

The fourth and final contribution actually disconfirms the role of risk management and supply chain orientation as important facilitating factors for supply chain resilience. The concepts of risk management and supply chain orientation was earlier identified from literature as the main facilitating factors for supply chain resilience (Park, 2011; Ponomarov, 2012). Indeed, the analysis shows very limited levels of supply chain orientation and risk management in these supply chains. Yet, it appears that these supply chains bounce back to (new) normal operations after disasters despite this lack of risk management and orientation. The reason could be the rather informal approach towards disaster management by all participants. It has been observed that supply chain network structures and social capital are the major facilitating components for the resilience of these supply chains. The presence of the hubs (wholesale markets), where actors share knowledge and provide non-institutional financial support to farmers, can be thought of as facilitating components of overall supply chain resilience. Emerging from this exploration of networks is a view of social capital that also facilitate the activities happening in these chains that are contributing to supply chain resilience. For example, at the hub level, social bonding capital is facilitating collaboration and knowledge management activities through trust and shared values. At a vertical level (between buyers and suppliers) bridging social capital fosters activities in all four areas. Similarly, these supply chain actors collaborate and share knowledge with the government and relief providers through linking social capital. Therefore, it can be said that social capital is vital for these networks to deal with disruptions, especially when local disaster management institutions are not well-developed in these regions and there is a general lack of active risk management and a supply chain orientation.

7.2.2 Operational and Policy Implications

This research on supply chain resilience has some explicit operational implications for supply chain members and policy implications for the government and relief providing organizations. The results revealed that supply chain resilience along the chain is fragmented. At an individual level, actors present in the wholesale markets, can be considered as the most resilient. The farmers are most vulnerable to natural disasters and they are also the least resilient. However, at a supply network level, these chains can be considered as resilient overall, as the resilience of one actor compensates for the vulnerability of another actor by providing them with the necessary support. Currently, the activities that contribute towards overall supply chain resilience are inherently present in these supply chains. However, to

increase or enhance resilience against disasters, supply chain actors should increase proactive resilience. Proactive resilience refers to those activities that are done in anticipation of a natural disaster. Supply chains need to take deliberate steps toward enhancing knowledge management, sourcing techniques and collaboration. For example, supplier development should be more rigorous, and information sharing should be more prevalent in these chains. Actors present in the markets should enhance the participation of buyers and sellers in decision making. The Jirga system is a good mechanism for resolving conflicts arising among these actors, but it should be more formalized, roles need to be clearly defined, and it should be fully backed by the government.

Additionally, most of the knowledge is tacit. Members of these supply chains should devise a plan to record or formalise this indigenous knowledge. There should be more dialogue (about the possible solutions of inefficiencies and removing the bottlenecks) among actors of these supply chains, researchers and decision makers to enhance the operations of these food networks. There should be training programs to enhance local capacities related to information and communication technologies. Supply chain actors should be assisted to attend workshops and seminars to promote dialogue (about possible collaboration and knowledge management). These measures can assist the conversion of tacit knowledge to explicit knowledge and also ensure it is available for all members of the network. Additionally, farmers and market members should foster more horizontal collaboration. It has been observed in this research that wherever farmers were united as a collective action force, they were listened to by the government and other policy makers.

The analysis shows that there is an abundance of readily available transport assets and companies in these networks. Yet, these are poorly managed and maintained and this increases the vulnerabilities of fresh produce spoiling or going to waste. While there are standardized procedures for packing food, the quality is poor, as are the food handling standards. These practices result in significant losses and improvements should be made in all of these areas to increase supply chain resilience.

There are number of policy implications for both local and provincial governments, as well as relief providing organizations. Local and provincial governments are major stakeholders in these supply networks and their roles become even more important when dealing with disasters. Currently, the poor building standards and codes have led, in the past, to heavy

financial and human losses during natural disaster events. The corruption index is very high in Pakistan, the literacy standards are very poor, especially at the farmers' level. These factors lead to the exploitation of farmers, as they cannot make use of the latest knowledge in their respective areas. As food wholesale markets are the most important nodes in these supply networks, the government should work with the supply chain members and include them in decision making processes. Although government representatives are part of the market committees, they should increase the level of collaboration beyond just the wholesale markets and regularize the processes. They should increase the level of research in these networks, so that while creating legislation, policy or setting prices, they have more accurate data related to actual supply and demand, social and economic conditions within these food supply chains. The government in region one (R1) has taken a few steps to provide information systems and knowledge databases for supply chain members, but only the larger actors are able to access these.

The local and provincial government also has a major role in harmonizing disaster preparedness and responses. Warning system are better for the floods, but a lack of awareness among supply chain members creates many problems such as insufficient preparation and poor response to disruptions. There are currently no warning systems for earthquakes and the lack of building codes and general awareness means that there are often disastrous consequences in the regions where these events occur. Closely associated to the government are public disaster management organizations and relief providers. In disaster-prone areas, both commercial and relief supply chains work side-by-side. Therefore, the interaction between both these chains is crucial for an effective response to disruptions. However, the roles of each supply chain are bit fuzzy in these areas. Although this research has presented examples of collaboration among food supply chains and relief providing organizations, there needs to be more formal forms of coordination. This could be achieved through education and awareness programs. If implemented, these measures will enhance the overall resilience profile of these food networks as well as the wider community.

7.3 Limitations and Future Research

The researcher acknowledges that this study has many limitations but believes that these provide opportunities for further research in this field. First, the research paradigm chosen for this study does not allow for generalization to the wider population. While this qualitative

research study has provided useful insight into the ways that these food supply chain members achieve resilience or not, this framework should be tested quantitatively in future research. Also, although the researcher sought advice from supervisors and peers on a regular basis, the empirical material was essentially interpreted by a single researcher. However, subjectivity is an expected artefact in the chosen philosophical paradigm and approach. Therefore, it is recommended that further research is conducted on these concepts to confirm the relevance of these current findings.

Furthermore, the findings of this study are based on just four case studies. However, within these four case studies, 37 interviews were conducted. While time in the field was a major limitation for the current study, all of the necessary steps were taken in order to reach the data saturation point. However, there are still thousands of members present in these supply networks, and this leaves considerable scope for repeat studies to discover more or different contributing factors for resilience, or even disconfirm the results of the present study. Another closely related limitation was the selection of certain food groups to study. This study has categorized all fresh produce items into one category, and staples into another. However, during the course of the study, it was seen that some of the products have quite different processes and properties and are treated slightly differently in these supply chains. Therefore, in future research special care should be given to the choice of products and product groups. Hence, researchers should choose carefully or focus on a single item in each category.

Further, the context of the study limits its findings to food networks only. While, the discussion and findings are no doubt developed at an abstract level, this research is still context specific. A closely related context, for example, is the dairy sector, as many farmers in these chains were also participants in the dairy supply chains as well. Indeed, future research still needs to be conducted on these closely related industries and supply chains to determine if these findings still hold true. The framework this research has presented can be used as an initial starting point, but the context of the research should be different, both in terms of industry and disaster.

Other challenges were related to data gathering and travelling regional including security issues. Researchers should have the local support from the army or government institutes in order to collect data from these areas. Familiarity with the local culture and language is absolutely essential to gain useful information. People are usually very friendly, but they are

afraid of, or reluctant to talk to strangers because of trust issues. This researcher advises approaching them through some common friend or some trustworthy government official, if one can be found.

Another interesting point that can confound the analysis is the frequency of disasters. Some of the disasters, like floods in the Punjab region, are so frequent that the local population have become very casual about these events and find it hard to differentiate these events from 'normal.' Thus, researchers in this field need to define what a disaster is, before conducting the interviews. This should differ for humanitarian researchers in a sudden onset disaster situation where the event is self-evident and is certainly not normal. Hence, in this type of fieldwork researchers should differentiate between those events that are 'normal', and those that are severe and have resulted in significant disruptions. Otherwise they will be talking to people who normally cope with disasters and see no difference from their business-as-usual situations.

Lastly, at times, it is hard to distinguish between different categories of food supply chains in the region, as most individuals are trading and doing business across multiple food items though multiple channels. Similarly, different supply chain actors are hard to clearly distinguish based on their roles. For example, the same firm behaves as a supplier and, at other times, as the buyer. This is especially true given the micro nature of many of the businesses, where respondents have to perform multiple roles. Therefore, the researcher must have local knowledge to differentiate between the various roles.

7.4 Final Remarks

The growing number of natural disasters will almost invariably cause major disruptions in food supply chains in developing economies. The underlying activities of the four main supply chain management areas, majority of which are part of inherent resilience of these food supply chains, contribute positively towards the overall supply chain resilience. In order to enhance the resilience of these food supply chains, this research suggests that proactive resilience, where supply chain actors deliberately attempt to prepare and respond to these disruptions, should be a focus for business and governmental policy. Additionally, network structures and especially social capital positively facilitate all the underlying activities that further contribute positively towards the overall food supply chain resilience. Finally, it is hoped that this study

will contribute, in some meaningful manner, to the ongoing debate of the concept of resilience overall, and specifically for food supply chain resilience in developing economies.

Appendix A

Data Reduction and Excerpt of Coding

A.1 Collaboration

Link to Supply Chain Resilience Capability	Data reduction (Interview Excerpts)	Second Order Coding	Link to Collaboration (Third Order Themes)
Reliability	"Good rate and deals well too...manners along with rates are very important...that is why they come back again and again...I say that it is due to the rate but 70% is due to the manners and dealing… therefore in difficult times we can rely on them because of previous good experience" (WS2-C2R2) "when we give stock to people on credit of 5 days or 10 days then if that party gives money in 10 days it is doing on regular basis then for us they are trust worthy" (Tr2-C2R1)	Good Work History	Building and Maintaining Trust: Affective Commitment
Visibility	"we do business with those with whom we are working since long... we trust them that they have worked with us earlier as well as we know their business" (Tr2-C2R1)	Length of Relationship	Building and Maintaining Trust: Affective Commitment
Adaptability	"Jirga is also called when farmer delays the payment and we compromise with the dealers, we ask both of them and we take undertaking that whatever Jirga will decide will be acceptable by both of you"	Jirga System	Building and Maintaining Trust: Conflict Resolution
Alignment	"Jirga consists of presidents of market, other respected elderly people of area, police representative, whenever there is any problem or conflict they sit together and try to take a combine decision." (WS1-C2R2)	Jirga System	Building and Maintaining Trust: Conflict Resolution

Velocity	"if report reaches police then they tell us that we have received a complaint from your market...will you be handling it yourself or we should write FIR? then we arrange Jirga and sort the issue out..."MC1-C1R2	Jirga System	Building and Maintaining Trust: Conflict Resolution
Visibility	"Trust is that we know your house is at so and so place, and they are doing good business, their crop is good, we have good relation with them...it is a kind of trust..." LS1-C2R1	Locality	Building and Maintaining Trust: Proximity and Bonding
Visibility	"we call it a "Pakka" customer means he is resident of this area and we know his work and we know from which family he belongs to"CA1-C1R1	Locality	Building and Maintaining Trust: Proximity and Bonding
Velocity	"local farmers who are close to the market bring their stuff as they don't get affected by the floods that much" (CA2-C1R2)	Locality	Building and Maintaining Trust: Proximity and Bonding
Alignment	"Because of flood, our supplier couldn't deliver on time, he called us and told that there will be delay so we support the supplier by not putting penalties because he had a genuine issue...he has informed before time...so his financial loss is covered by this way" (Rt1-C1R1)	Delayed Delivery	Building and Maintaining Trust: Recognising Common Vulnerabilities
Flexibility	"We impose some financial penalties on our suppliers if they fail to deliver on time or if there is some issue with the quality. However, in case of natural disaster, we are very much flexible". (Rt2-C1R1)	Quality Compromise in Disaster	Building and Maintaining Trust: Recognising Common Vulnerabilities
Adaptability	"When some of our suppliers were out of business then we contacted suppliers from Punjab to directly send us the items, we keep record of those people and in difficult times it helps us to deal with the new situation" (WS4-C2R2)	Effective Role of Telecom and Media	Effective Communication & Information Sharing
Flexibility	"We mostly connect with our buyers through mobile phone, it is more easy and it saves us lots of time and energy to travel to these areas. We develop the relationship and then be in contact through cell phones" (WS2-C2R2) "If there is severe shortage we get facilitation from internet that where there is availability of required things... like where we can avail in the world... wherever we got it... like we got it from Dubai we took, we got directly from Philippines, from India, wherever we get we took... in whatever quantity... we kept on taking it..." (CA1-C1R1)	Effective Role of Telecom and Media	Effective Communication & Information Sharing
Velocity	"Our all work is done on phone… we have direct dealing with broker and factory as well... at times we buy from broker and then we buy direct from factory as well... we ask them for samples... they send us... after looking at the thing we talk to him	Effective Role of Telecom and Media	Effective Communication & Information Sharing

	about the rates... then we get the stock… then we check the stock and if it matches with the sample we send him the payment in couple of days...” (WS3-C2R2)		
Adaptability	“Commission agent has invested in them so the farmers are not in position they can pay back the debt so based on our recommendation, Commission agent relax the payback time. every one wait for the next year and we trust our God that he will give us the prosperity next year.” (MM1-C1R1)	Mutual dependence	Effective Communication & Information Sharing
Alignment	“However, because of the trusted sustainable buyers and suppliers, also because of dependency on each other being part of same supply chain, their supplier and buyers shared that missing information with them.” (LP1-C1R2)	Mutual Dependence	Effective Communication & Information Sharing
Visibility	“We have a representative in all KHI markets... it is his duty that he has to go to market and get the best rate... if there are commission agents then he has to be part of auction and if there is no commission agent then he has to discuss it with them... because you know these are perishables that get ruined in one day so it has to be done on daily basis in order to get the best rate for our end consumers... in every market in Faisalabad, Ravi, Karachi, Islamabad..” (Rt1-C1R1)	Supply Network Knowledge	Effective Communication & Information Sharing
Alignment	“Although we sell most of the items to middle man but we know who are the buyers of that middleman… what are their requirements and what sort of customers they are serving” (Fr1-C2R1)	Supply Network Knowledge	Effective Communication & Information Sharing
Flexibility	“In event of any natural calamities, our suppliers are totally relaxed in returning the money to us, we give them extra time” (Pr1-C2R1) “We have several weak retailers and we help them in every manner. Incentive that we have for them is that we will unload the articles and we work on net rates basis”. (Br1-C2R1)	Access and Availability of Financial Sources	Non Institutional Financial Support
Velocity	“When farmer is affected, then it direct affect us as we have invested in the farmer and also when no crop comes into the market we cannot get any commission on anything. Therefore, we again help them financially so that they can stand on their feet again quickly to start delivering the products to us”. (CA2-C2R1) (CA1-C1R2)	Access and Availability of Financial Sources	Non Institutional Financial Support
Alignment	“We invest in the farmers after carefully monitoring his financial strength and way of working, if he is reputed and has good processes then we invest on him, sometimes middle-man tell us that we should invest on this farmer” (CA3-C1R2)	Access and Availability of Financial Sources	Non Institutional Financial Support

Adaptability	"With last flood we were having very poor business, so we started supplying the fertilizers, we also provide this fertilizers to our suppliers which are farmers in this case as well. It is because they don't have access or resources to buy that fertilizer, this fertilizer really helped us and we regularly started investing in it." (CA1-C2R1)	Buyer Becoming Supplier	Non Institutional Financial Support
Flexibility	"These is lot of cheap labour available, they are local people and they are expert in multiple duties, they help us grow the crop as well as plucking and packing, sometimes when there is no work we find them work in some other place" (MM-C1R1)	Availability of Labour	Utilizing Network Resources
Velocity	"Because of plenty of availability of labour in the market, we often find no difficulties in getting people to load our trucks, some of this labour belongs to commission agent but we hire them on daily wages basis to get our work done." (Rt-C1R1)	Availability of Labour	Utilizing Network Resources
Velocity	"It is the duty of supplier to manage everything. But sometimes in case of emergency we send our own transport to collect." (Tr-C2R1)	Resource Sharing	Utilizing Network Resources
Alignment	We regularly communicate with other commission agents and share information such as which crop is going good, about suppliers and if we have information about disaster then we also tell to other people in market. (FrR1)	Info Sharing with Competitor	Coopetition: Communication and Info Sharing
Flexibility	"Now here the system is that as soon as farmer gives vegetable to commission agent… another commission agent invests with him... for instance you have 10 trucks… you say to another commission agent I have 10 trucks if you want to invest then you can take 3 trucks from me." (GR1-C1R1)	Buying from Competitor	Coopetition: Financial Support
Adaptability	"In difficult times, when our competitors have financial issues then we help them financially like loans so that they can invest on their suppliers or buy stuff from farmers, similarly if we are in trouble then they help us" (CA3-C1R2)	Interest free loans	Coopetition: Financial Support
Velocity	"Their shop was destroyed in earthquake of our neighbour, we helped him by collecting money from everyone so that he can build his shop again" (CA1-C1R2)	Helping him in Disaster Response	Coopetition: Financial Support
Alignment	"We have a shop and there are 20 middle men at our shop... those 20 middle men hire an accountant... we have our own accountants who serve us... but they trust little on them and hire their own representative as well" (CA2-C1R1)	Common Resource	Coopetition: Resource Sharing

Alignment	“It is market's cars... small van... it moves around in the market and pick from other whole sellers as well... we have trust in it... we give him 40 sacks with worth of PKR 4000 each” (WS1-C2R2)	Transport Sharing	Coopetition: Resource Sharing
Adaptability	“Large amount of mud in last flood which came with water was huge problem and we have a lot of money on clearing that mud, we all come together and contributed and hired a company to get rid of that mud. We also used our own labour to clear out the water and mud.” (CA1-C1R2)	Common Investment	Coopetition: Seeking Common Solutions
Alignment	“There is Swat river... you will see... we all people have 2 to 3 channels for us… Government did not… we developed our own irrigation system and from the same every person irrigates land according to one’s personal needs, there was many problems related to irrigation and also electricity doesn’t come sometimes, so we all farmers have combined together to invest in these channels so that everyone can have benefit out of this” (Fr1-C1R2)	Common Investment	Coopetition: Seeking Common Solutions
Reliability	“In case of demand fluctuation, government maintains the prices in the market and also the regularize the maximum amount of item we can give to a customer” (GR1-C1R1) “We go to godowns where people stock the things... we check them... we take things out from there and we also impose penalties if quality is not good or people have stocked in time of high demand.” (GR1-C1R1)	Check and Balance	Government Support
Velocity	“In case of emergency, we get some of the things in the form of aid and also we import things from abroad... we import and then till things are not settled...” (GR2-C1R1)	Check and Balance	Government Support
Velocity	“Govt announces special packages for farmers after major disaster it can be in form of cash and there are also loan program from bank, this helps the farmers to spring back quickly” (CA3-C1R2)	Financial Support by Govt.	Government Support
Adaptability	“Government does not have interest in it... maximum what they do is that whatever stock they buy from them they make it tax free... nothing is gained of this...” (CA2-C1R1)	Financial Support by Govt.	Government Support
Reliability	“If the road is ruined...like when there was flood in Malakand...this time when I went I saw very nice bridges have been built... they have worked a lot... but they can’t work to this extent during emergency... they have to look after people and can’t do construction...” (WS2-C2R2)	Improving Physical Infrastructure	Government Support

Adaptability	"At that time main issue was with Punjab... their market has major issues... whatever stock was sent to balakot was sent as an aid... trucks were stuck for so many days... ways were blocked... we were not in contact with them… but we knew it was due to serious problem so we accepted all the loss" (WS2-C2R2)	Accepting Delays	Collaborating with relief chains: Facilitating Relief Process
Flexibility	"In some cases what we have done is that we get orders and we make those hampers and supply those hampers directly to affected areas... but 90 to 95% cases we give to suppliers and then they distribute via their own distribution networks or via third party systems whatever is their system. hamper is basically a box... where there are 2 kg rice, 3 kg sugar, 2 kg ghee and spices is added in to that box... basic commodities for relief... that one may eat for a week" (Rt1-C1R1)	Help in Distributing Relief Items	Collaborating with Relief Chains: Facilitating Relief Process
Velocity	"As soon as earthquake hit, people come after couple of days or after a week and access us... they ask us what they want? in what quantity they want to help the affected people... for instance they say we need 1000 kg each... like 1000 kg rice, 1000 kg pulses, 1000 kg wheat... we make each packet of kilo... we say that we will get everything ready and we fulfil this demand because we have backup solutions we have reserved labour for this" (WS1-C2R2)(WS3-C2R2)	Quick Demand Fulfilment	Collaborating with Relief Chains: Facilitating Relief Process
Flexibility	"We are flexible about the prices in difficult times, especially when some companies who provide relief in these areas they come to us then we give them discount, and we also give them free considering that this is also our responsibility" (CA2-C1R2)	Supplying Low Cost Products	Collaborating with Relief Chains: Facilitating Relief Process
Adaptability	"We have an awareness program for farmers and commission agents. We also start program for customers so that they don't buy more in panic. We limit the purchase per customer and also try to maintain the price" (GR1-C1R1)	Awareness Programs	Collaborating with Relief Chains: Facilitating Local Food Chains
Adaptability	"When there was an earthquake than National disaster management and other agencies prefer to procure food items locally, because bringing food from other areas or countries is time consuming, we have helped many agencies to get local food from our market' (MC1-C1R2)	Local Procurement	Collaborating with Relief Chains: Facilitating Local Food Chains
Adaptability	"In recovery phase, when farmers are in great trouble because of limited resources then international relief providing companies provide them seeds and fertilizers which help them adapt to the new situation." (CA3-C1R2)	Providing Raw Material	Collaborating with Relief Chains: Facilitating Local Food Chains
Velocity	"When bridge was destroyed then they unload the products in small trucks and then in small boats to reach to the other side of the bridge. Those boats belong to the army. Army also makes the temporary bridges there." (LP1-C1R2)	Restoring Transportation	Collaborating with Relief Chains: Facilitating Local Food Chains

A.2 Knowledge Management

Link to Supply Chain Resilience Capability	Data reduction (Interview Excerpts)	Second Order Coding	Link to Knowledge Management (Third Order Themes)
Adaptability	"With latest research, now lots of vegetables are available throughout the year, similarly researchers have also found a form of rice which can survive extra amount of water and excessive rain doesn't damage it" (Fr2-C2R1)	Centres of Expertise	Knowledge Acquisition
Reliability	"As the information about latest trends and natural disasters comes from government departments, therefore we can rely on it" (CA2-C1R1)	Centres of Expertise	Knowledge Acquisition
Adaptability	"Flood brings rich nutrition solid with it, even our crops totally got destroyed but next year with good quality seed and soil, we achieved greater yield" (FR1-C1R1) "We improve it time to time e.g. as i told you that we have sewerage system to drain the rain water so that the rain water goes out to a bigger canal. Similarly, rather than soil we have there brick powder which is called "kery" it is there. It does not cause slippery or marshy land. It withstands. according to fire-fighting approach and learning experience we have done all these things" (Pr1-C2R1)	Learning	Knowledge Acquisition
Alignment	"We imported the fresh produce from India, because of severe weather in Sindh province, our supplies were zero, this new produce was expensive but our buyers both wholesalers and retailers understood that it is needed of time to survive in the market, therefore they understood, no doubt profit was low but we survived" (WS1-C1R1)	Learning	Knowledge Acquisition
Velocity	"We had a round in all areas when there was flood. We took a boat and with rescue we went for a round. We saw places where there was not water in certain areas. And also PDMA helped us give up to date information, we were able to quickly	Learning	Knowledge Acquisition

	adapt to the new situation, we imported items for other areas and helped our farmers to get to their feet again." (Br1-C2R1)		
Adaptability	"We have mostly family business, everyone is associated with each other and in our religion we also consider other as our brother, therefore it helps to share information with each other also helping each other to survive and get back to their feet" (Fr1-C1R2)(CA2-C2R1)(WS3-C2R2)	Culture	Knowledge Infrastructure Capabilities
Adaptability	"Because we are working in the market and we were farmers before, we have the knowledge of different aspects of business, this market structure help us to easily switch our business and also sometimes we deal in multiple products and diversified products to help sustain in this business" (CA2-C2R1)(WS3-C1R1)	Structure	Knowledge Infrastructure Capabilities
Velocity	"We mostly contact our suppliers and buyers over the cell phone which really help us to share the important information with each other, there are websites and other information systems mainly in our region which give us useful information to stay up to-date with the latest trends" (MC1-C1R2)(WS3-C2R2)	Technology	Knowledge Infrastructure Capabilities
Alignment	"For example our quality assurance department does not only go to check him but to guide him as well... that you might increase the sale by improving these things... we guide him about let's say you are giving me 120 rupees and another is giving me 115 rupees then we guide them that may be your sourcing is not right... maybe you are taking stock from somewhere not appropriate... you might try to take from these several places..." (Rt1-C1R1)	Guiding and Training	Knowledge Sharing
Reliability	"We guide our suppliers about their sourcing strategies, this increases the quality of the product and also prices are less which leads to increase sale." (Rt1-C1R1)	Guiding and Training	Knowledge Sharing
Alignment	"Because we sit in the same market and wholesaler are in direct contact with retailers and customers, they share their demand with us and we give orders to our suppliers accordingly" (CA1-C1R1)(GR1-C1R1)	Socialization	Knowledge Sharing
Visibility	"Upstream and downstream partners come to visit market regularly, they exchange information and also come to know about each other processes. Therefore our	Socialization	Knowledge Sharing

	buyers sometimes demands that if we have item from this supplier then they pay even more" (Tr1-C2R1)(CA2-C1R2)		
Velocity	"In events of natural disasters, there is a shortage of food items in the market and prices become high. He knows his customers demand so he brings product in accordingly. "(CA1-C1R2)(LP1-C1R2) "This Rice Mills has 6 departments of Pakistan i.e. air force, navy, rangers, Punjab Police, Army, utility stores and Hajji Camp etc. as main customers they have annual contract. Contracts are with the beginning of the season. For instance, this is the beginning of the season then think that there is no more paddy in the market and they have their orders. they know that we have to send this much stock in the army on monthly basis, because of their efficient forecasting" (Br1-C2R1)	Forecasting	Knowledge Utilization
Velocity	"we have the full knowledge how market works, in adverse cases we bring items from India and Philippines sometimes because we keep an eye on their rates and we know how to procure from there" (Fr1-C1R1)	Market intelligence	Knowledge Utilization
Reliability	"Seed adapts according to the land after 2 to 3 years... after 3822 type there was basmati 2000... its height used to be too much... it used to fall on land... its plant used to spread... those who are common grower even they have 35 to 40 yield... they take more yield because they keep things in their mind because they rely on latest product development and research" (Fr2-C2R1)	Product Improvement	Knowledge Utilization
Flexibility	"In case of adversities we some time buy few items within the market and sell the products further to retailers or whole sellers based on the contacts we have established in the market." (MM1-C1R1)	Switching the role	Knowledge Utilization

A.3 Logistics

Link to Supply Chain Resilience Capability	Data reduction (Interview Excerpts)	Second Order Coding	Link to Logistics (Third Order Themes)
Flexibility	"We keep one week's stock that anything can happen any time so we take care that we don't get in to stock out position...so it is just not about the natural disasters but it is that economy of Pakistan and other circumstances" (Rt1-C1R1)	Backup Resources	Backup Solutions
Velocity	"...there can be accident or something goes wrong with the engine or machine... then they load another truck or fix the same truck and send it... if there is any loss then middle man is responsible… truck person is not responsible…" (CA3-C1R2) "Once or twice lightning struck our farm in rainy season. As you know in first place it affects your transformers so we have back up generation. We have two stand-by generators for that purpose. We have emergency tools stores so that if we can't go to market to buy them so we must have them for the replacement." (Pr1-C2R1)	Backup Resources	Backup Solutions
Flexibility	"Yes we have contracts, they send us the vehicle according to our demand and we have number of transport companies to handle these situations." (Pr1-C2R1)(CA2-C1R1)	Multiple Contracts	Backup Solutions
Velocity	"Because one is that there is disaster... every disaster brings hamper to Metro that is huge quantity... there when we tell the supplier there is disaster and now your hamper of so and so worth will be sold in ten days... we are giving you this much volume then obviously we will be his preference..." (Rt1-C1R1)	Inventory Adjustments	Inventory and Storage Adjustments
Alignment	"We have middleman, they do the product grading when the items reach to this market, as we share information with each other so our suppliers know what is the demand of one item, they only bring that item to the floor and rest of them goes to the storage" (CA2-C1R1)(CA3-C1R2)	Inventory Adjustments	Inventory and Storage Adjustments

Flexibility	"Products are categorized based on the location, quality and size, the products which are not good they are sold separately." (CA2-C1R1)	Inventory Adjustments	Inventory and Storage Adjustments
Alignment	"…like when there was flood in Peshawar... then best thing was that we had stock with us… it was the first thing that helped us... so whoever suppliers work with us we always ask them to stock of it at their place... so we do not actually get in to much trouble in any situation…" (Rt1-C1R1)	Stocking at Supplier Site	Inventory and Storage Adjustments
Flexibility	"Almost every trader (commission agent) has sufficient space in the market to store produce for a few days (free of cost) or for longer periods for a nominal charge." (CA1, CA2-C1R1)	Temporary Storage	Inventory and Storage Adjustments
Flexibility	"Yes we have contracts, they send us the vehicle according to our demand and we have number of transport companies to handle these situations." (Tr1-C2R1)(CA1-C1R2)	Availability and Mode of Transportation	Multiple Transportation Facilities
Velocity	"It is the duty of supplier to manage everything. But sometimes in case of emergency we send our own transport to collect. If someone is dealing directly with farmer then 99 percent it is your duty to arrange transports." (Tr1-C2R1)	Availability and Mode of Transportation	Multiple Transportation Facilities
Flexibility	They tell us the demand like if you have raw form of rice then keep on sending us. We have a target of 2 lac sacs. either complete it in 10 days or 15 days, we are comfortable with the late delivery but it should be quality rice" (Br1-C2R1)	Delivery Flexibility	Multiple Transportation Facilities

A.4 Sourcing

Link to Supply Chain Resilience Capability	Data reduction (Interview Excerpts)	Second Order Coding	Link to Sourcing (Third Order Themes)
Flexibility	"Yes they have other people in backup with whom they deal on and off... like they came to know that Ramadan is approaching and demand will be more... from whom they take… he failed to meet their demand for supply… therefore they will go to other supplier... they will keep relation with them... but they have one or two who are their main source..." (GR1-C1R1)(Rt1-C2R1)	Backup Suppliers	Rationalizing Supplier Base
Velocity	"I don't depend on one supplier in one time. There are ample of feed mills in closed vicinity. There are 3 to 4 large mills in Lahore. There are in Faisalabad, Gujranwala so we have developed lines over the industry like first line, second line, third line suppliers. If I am taking from my mill does not mean I never talk to them. Every month I take two cars from them as well just to maintain a relationship. At times my mill is closed then we have a second line of supply. We have all the contacts. we have proper contracts with procurement managers of the other mills and time to time we operate them as well" (Pr1-C2R1)	Backup Suppliers	Rationalizing Supplier Base
Visibility	"Next time even if he has come with intention of deceiving but he took stock for cash so that next time he would do something even then we will give him... we go to parties and we see if the party is weak... we tell them clearly that we will not give the stock next time but when they come we can't refuse" (WS3-C2R2)	Enhancing Supplier Base	Rationalizing Supplier Base
Alignment	"However, we have developed multiple suppliers in the market, we give them training." (WS2-C2R1)	Enhancing Supplier Base	Rationalizing Supplier Base

Reliability	"Just based on the mutual trust and relationship we have with the farmer and also if he has a good crop. We also check his credit check, his reputation and also if he does put extra efforts to have his crops according to good standard." (MM1-C1R1)	Enhancing Supplier Base	Rationalizing Supplier Base
Velocity	"Due to the floods and non-availability of infrastructure, the industry has started to develop in the surroundings of the cities. Vicinity of Lahore has many farms at industrial levels with modern technological facilities. Similarly, there are very few in North side of this city as there is not much space there. Then if you go to northern areas there are even lesser hence when you go upwards from Punjab or Lahore, then rates get higher. Similarly, when you move towards southern Punjab and Karachi then rates again get higher. So this industry is in ample in central Punjab due to favourable weather conditions, agri-feed, fodder and population. Because it is a huge market. So that is why cluster here is huge." (Pr1-C2R1)	Logistically Efficient Places	Rationalizing Supplier Base
Flexibility	"I have 100 of suppliers. We have categorized it into two. One set of suppliers are from Punjab and others are from Sindh province." (Tr1-C2R1)	Wide Supplier Base	Rationalizing Supplier Base
Flexibility	"Supplier as a supplier that once you gave business is over... it is a win-win situation with supplier... so you give him a grace period that if you improve so and so things then after 3 months you become eligible to participate in tender... if he is a kind of supplier where there is no room of improvement or if there is not any of his willingness then we reject... if he improves then afterwards a tender is floated to suppliers... then they give us quotation and samples of those." (Rt2-C1R1)	Delivery and Volume Flexibility	Sourcing Flexibility
Flexibility	"We don't deal in one item... we deal in all vegetables... if carrots are ruined then we will have turnip, radish, spinach, this is how all vegetables come as a mixture..." (Fr1-C1R1)	Diversified Product Portfolio	Sourcing Flexibility
Adaptability	"If one crop is destroyed in disaster then we do have some knowledge of other products therefore we start procuring that and run our business" (Rt1-C2R2)(CA1-C2R1)	Diversified Product Portfolio	Sourcing Flexibility
Velocity	"In adverse conditions if there is a shortage of one supply then I buy items which come from Punjab and keep my business running." (CA1-C1R2)	Multiple Channels	Sourcing Flexibility

	"Gradually after the disaster these middle men came… even now landlords bring but at very low level... like 5 or 10% in 100%... who are keen to earn as much as possible from their crop or if there are crisis on some particular crop." (CA2-C1R1)		
Flexibility	"This is what I am telling you... if flood is in divisions like Layyah, Rajanpur, Muzaffargarh...Punjab has 8 or 9 divisions... if there is no flood in one division then we get things from other divisions and do things." (WS3-C1R1) "...Perishable goods can't be stored... how will they store spinach, coriander, cabbage, bitter gourd... it is not done... what happens is that they go to carts… he is to work all day long and has to earn from 500 to 1000 rupees..." (CA2-C1R1)(CA2-C1R2)	Multiple Channels	Sourcing Flexibility

Appendix B

Interview Protocol

B.1 English Version

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Dealing with Disasters: Building Resilient Food Supply Chains

Semi-Structured Interview Protocol

The purpose of this study is to understand the factors which contribute towards the resilience of food supply chains in the advent of natural disasters. This study will find out supply chain capabilities and facilitating factors contributing to supply chain resilience. Some of the outcomes of the supply chain resilience will also be taken into consideration. An enhanced conceptual framework will also be proposed at the end of this research which will help food supply chains to achieve higher level of resilience.

Section 1: Background Information of the Corresponding Organization (Secondary sources like internet searches & company website will also be used).

Basic Information:-

- Company/Department/Business
- Respondent's Name/Position
- Main Competitors

- Sales and Profit
- Number of Employees
- Product Range and Categories
- Other Stakeholders (Local Government, Local Committee, Other Government Officials, NGOs, Associations etc.)

Information about the Supply Chain:-

- Upstream Supply Chain Actors
- Downstream Supply Chain Actors
- Logistic Providers (Volumes Of Freight, Transport Types & Frequency)

Section 2: Perception and General Ideas About Resiliency

- What was the recent disaster you have faced?
- How and when did you find out about the disaster?
- Your initial thoughts and reactions?
- Any prior preparation? Were your staff members prepared for the disaster? Were your supplier, distributor prepared?
- How did your customers react?
- Effects on your company? Short term and long term?
- Did you bounce back to original state (processes, resources, relationships) or modify into a different state?
- What did you learn from this crisis?
- What did you do to prevent any future disruption?

Section 3: Finding Out the Vulnerabilities That Challenge the Food Supply Chains:

- Can you identify some of the vulnerabilities in your supply chain due to recent disaster you have faced?

Section 4: Supply Chain Capabilities Which Help Achieve Supply Chain Resilience:

- How do you deal with all the vulnerabilities (mentioned in previous section) in your supply chain?
  (Techniques? Relationships with supply chain actors? Relationship with Government/private agencies? Sourcing? Logistics? Dependency on any big organization? Any central information system? Got any relief?)

Prompts:

Prompts for Section 3:

Questions	Label	Reference
Were there any unpredictable demand or supply shifts?	**Supply and Demand Vulnerabilities**	(Hamel & Valikangas, 2003; Peck, 2005; Pettit et al., 2010; Sheffi & Rice Jr, 2005; Svensson, 2000)
Logistic issues? Physical infrastructure?	**Logistics Vulnerabilities**	(Benini et al., 2009; Kovács & Spens, 2007)
Technology? Electricity? Internet or cell phone?	**Internal Vulnerabilities**	(Pettit et al., 2010)
External pressure from competitors/Government officials/stakeholders?	**External Vulnerabilities**	(Hamel & Valikangas, 2003; Peck, 2005)
Resource limitation? Production capacity/suppliers capacity/raw material	**Internal and External Vulnerabilities**	(Pettit et al., 2010)
How do you assess the vulnerabilities in your supply chain?	**Vulnerability**	(Christopher & Peck, 2004)

Prompts for Section 4:

Organizational point of view:

Questions	**Label**	**Reference**
What sort of hazards/emergencies do you think this organization is exposed to?	**Vulnerability, Organization Resilience**	(A. V. Lee, Vargo, & Seville, 2013)
What sort of external aid is available to this organization including insurance?	**Agility, Organization Resilience**	(H. L. Lee, 2004; Webb, Tierney, & Dahlhamer, 2002)
Does this organization engage in any planning prior to the disaster? Any formal emergency plan or risk management plan?	**Organization Resilience, Alignment**	(Christopher & Peck, 2004; Sutcliffe & Vogus, 2003)
How well you are prepared against the loss of internal services like power, telecommunication, water, sewerage or any other physical infrastructure?	**Organizational Resilience**	(Kneafsey et al., 2013)
How do you manage to retain or hire new staff in these situations?	**Organization Resilience**	(McManus, Seville, Brunsdon, & Vargo, 2007)
How effective are relationships among different departments, external stakeholders and how effective are the communication channels?	**Collaboration, Supply Chain Orientation**	(Maon et al., 2009)
Do you maintain sufficient resources to absorb unexpected changes?	**Agility**	(Peck, 2006)
In what ways did behavioural factors influence during response stage? Did these factors facilitate or hinder during the response?	**Collaboration**	(Reich, 2006)

How the survivals of other companies in your supply chain effect your organization?	**Supply Chain Resilience, Coordination**	(Jahre, 2009; Xu & Beamon, 2006)
How do you think survival of your organization contribute to the overall supply chain in disaster?	**Alignment, Coordination**	(Balcik et al., 2010)
Do you trust your key suppliers and customers and do you think they trust you? What do you mean by trust?	**Collaboration, Logistics, Sourcing**	(Scholten et al., 2010)
Do you give priority to establish good relationships with your key customers/suppliers?	**Sourcing, Alignment, Adaptability**	(Kinsey, Kaynts, Ghosh, & Agiwal, 2007)
Does the top management of this company reinforce the need of building, maintaining and enhancing good relationships with your supply chain members?	**Supply Chain Orientation**	(Esper, Clifford Defee, & Mentzer, 2010)
Do the top managers reinforce the idea of sharing information with key supply chain members?	**Supply Chain Orientation**	(Ponomarov, 2012)
Do you try to maintain similar culture and structure in your organization as that of your other supply chain members?	**Supply Chain Orientation**	(Esper et al., 2010; Ponomarov, 2012)

Supply Chain Point of View:

Questions	**Label**	**Reference**
How do your suppliers help you preparing for the disaster?	**Preparedness, Agility, Collaboration**	(Mentzer et al., 2001; Ponomarov, 2012)
Do your supplier help in responding the disaster and how?	**Response, Collaboration**	(Rice & Caniato, 2003)

Do you prefer to have single reliable supplier or multiple suppliers?	**Sourcing, Agility**	(Fiksel, 2003)
Do you know the suppliers of your supplier? Have you tried to make relationship with them?	**Agility**	(Chopra & Meindl, 2007; Pettit et al., 2010)
If your customer is not end user, do you know customers of your customers? Do you also consider the needs/wants of them?	**Agility, Alignment**	(Peck et al., 2003)
Do your customers help you prepare and respond in disaster?	**Agility, Adaptability**	(Abe & Ye, 2013; Oloruntoba & Gray, 2009)
What do you think is the most critical product for your organization and why?	**Sourcing, Logistics**	(Oke & Gopalakrishnan, 2009)
How many suppliers deliver this product? Where are they located? Do these suppliers have other important customers as well?	**Logistics, Agility, Alignment**	(Park, 2011)
Do you think your suppliers are also in contact with each other? Do you play any role in making this contact effective? Or do you face any problem?	**Collaboration, Knowledge Management**	(Ponomarov, 2012; Sodhi & Tang, 2013)
Do you have some storage capacity to store certain products during disasters?	**Agility, Adaptability**	(Day et al., 2012)
Who are your competitors? Do you support them or take their support during disasters? If you have any same customers, do you share information with each other or is there any combined strategy?	**Information Sharing, Collaboration, Agility**	(Christopher & Peck, 2004; Fiksel, 2003)
Who is your logistics provider? Do you have your own vehicles? What sort of difficulties you face from them?	**Logistics**	(Akhtar et al., 2012; Christopher, 2012)

What is most important factor for you in turbulent time?	**Supply Chain Resilience**	(Ponomarov, 2012)
How to you predict demand in turbulent times? Do you have the capacity to adjust product volume accordingly?	**Adaptability, Alignment**	(Clay Whybark, 2007; Peck, 2006)
Are you able to introduce new products or made necessary adjustments in existing ones?	**Adaptability**	(Christopher & Peck, 2004)
Does your customer allow you to have flexible delivery times?	**Knowledge Management**	(Mentzer et al., 2001)
Do you think you are a reliable supplier or customer?	**Collaboration**	(Rice & Caniato, 2003)
Do you share any sort of information with your suppliers/customers and how often you do so?	**Knowledge Sharing**	(Mentzer et al., 2001; Ponomarov, 2012)
Do you take any assistance from NGOs/Govt. agencies/relief providers?	**Collaboration with Relief Supply Chain**	(Moore et al., 2003)
Do you share information with these institutes? Do you collaborate with each other in some situation?	**Collaboration with Relief Supply Chain**	(Roy et al., 2012)

B.2 Urdu Version

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Dealing with Disasters: Building Resilient Food Supply Chains

Semi-Structured Interview Protocol

اس تحقیق کا مقصد ان عوامل/عناصر کا پتا لگانا ہے جوقدرتی آفات کی صورت میں خوراک کی ترسیل کے عمل کو لچکدار بناتے ہیں اس کی صورت میں جو نتائج نکلتے ہیں ان کو بھی زیرے غور لایا جائے گا اس کے علاوہ یہ بھی جانچا جائے گا کے خوراک کی ترسیل کا نیٹ ورک قدرتی آفات کی صورت میں بننے والے امداد پہنچانے کے نیٹ ورک سے کیسے تعاون کرتے ہیں اس تحقیق کے اختتام پر ایک ایسا بہتر لایحہ عمل بنایا جائے گا جو کے خوراک کی فراہمی کے سلسلے کو زیادہ سے زیادہ نتایج حاصل کروائے گا

سیکشن ۱: رسرچ میں حصہ لینے والی تنظیم / کمپنی کا پس منظر:-

بنیادی معلومات:-

- **کمپنی / ڈیپارٹمنٹ / بزنسس/ کاروبار کی قسم**
- **معلومات فراہم کرنے والے کا نام اور پوزیشن**
- **اہم حریف / مد مقابل**
- **سال میں فروخت اور منافع**
- **ملازموں کی تعداد**
- **مصنوعات کی تعداد اور اقسام**
- **دیگر سٹیک ہولڈر (مقامی حکومت ،مقامی کمیٹی ، دیگر حکومتی نمائندے ، این جی او)**

ترسیل کے نظام کے بارے میں معلومات:-

- ادارے جو جو آپ کو مصنوعات فراہم کرتے ہیں
- ادارے جو آپ نے مصنوعات لے کر آگے پہنچاتے ہیں
- نقل و حمل مہیہ کرنے والے (حجم، اقسام، کثرت یا فریکونسی)

سیکشن ۲ : لچک کے بارے میں بنیادی سوچ اور ادراک :-

- آپ کو حال ہی میں کونسے بحران کا سامنا ہوا؟
- آپ کو اس بحران کے بارے میں کیسے اور کب پتا چلا؟
- آپ کی فورا سوچ اور ردعمل کیا تھا ؟
- آپ نے اس بحران سے نمٹنے کے لیے کیا تیاری کی تھی ؟کیا آپ کے ملازمین تیار تھے ؟
- جو ادارے آپ کو مصنوعات فراہم کرتے ہیں اور جو آپ سے لیتے ہیں (خریدار، ڈسٹریبوٹرز) کیا وو تیار تھے؟
- اس سانحہ کے آپ کے کاروبار پر مختصر اور طویل مدت کے کیا نتائج آے ؟
- اس بحران سے نمٹنے کے بعد آپ پہلی جیسی حالت میں واپس آگئے ؟ یا آپ پہلے سے زیادہ بہتر ہو گئے یا حالات زیادہ خراب ہو گئے؟
- آپ نے اس بحران سے کیا سیکھا ؟
- مستقبل میں کیا آپ پہلے سے زیادہ اچھے طریقے سے اس طرح کے قدرتی عمل سے نبردآزما ہو سکتے ہیں؟

سیکشن ۳ : خوراک کی فراہمی کے سلسلے میں آنے والی رکاوٹیں اور خطرے :-

- کیا آپ اپنی سپپلائی چین میں حالیہ قدرتی آفت کی وجہ سے آنے والے خطرات/رکاوٹیں شناخت کر سکتے ہیں؟

سیکشن ٤ : مصنوعات کی فراہمی کے سلسلے کی خصوصیات جو کے لچک حاصل کرنے میں مددگار ہو :-

- آپ کیسے ان خطرات سے نبٹتے ہیں جو آپ نے پچھلے سیکشن میں بتائی ہیں

(خاص تکنیک، اپنے ساتھ کاروبار کرنے والوں کے ساتھ تعلق، گورنمنٹ یا نجی اداروں کے ساتھ تعلق، خام مال کے زریعے، کسی بڑے کاروبار پر انحصار، معلومات کی فراہمی کا کوئی مرکزی نظام، نقل و حمل کے زریعے؟)

حسب موقع/موزوں سوالات :-

سیکشن ۳ سے متعلق حسب موقع سوالات:-

- کیا کوئی ڈیمانڈ یا سپلائی میں غیر متوقع اتار چڑھاؤ ہوا ؟
- ذرائع نقل و حمل میں کوئی مسلہ ؟ بنیادی ڈھانچہ (سڑکیں، پل وغیرہ) میں مسلہ ؟
- ٹیکنولوجی، بجلی، انٹرنیٹ یا موبایل سروس کا کوئی مسلہ ؟
- گورنمنٹ کی طرف سے یہ مد مقابل یا دوسرے کسی سرکاری/نیم سرکاری اداروں کی طرف سے کوئی پریشر؟
- وسائل کی قلت یہ پیداوار کے حجم یا سپپلائر کی پیداواری گنجائش سے مطلق کوئی مسلہ ؟
- اپنی مصنوعات کی فراہمی کے سلسلہ میں ان سب خطرات کا تشخص کیسے کرتے ہیں؟

سیکشن ٤ سے متعلق حسب موقع سوالات:-

کاروباری نقطہ نظر:-

- آپ کو کسی طرح کی کوئی بیرونی امداد ملتی ہے یا کوئی بیمہ پالیسی ہے آپ کے پاس؟
- آپ اپنے اندرونی نقصانات جیسے بجلی، پانی، ٹیلیکوم، عمارت کو نقصان وغیرہ کے لیے کتنے تیار ہوتے ہیں؟
- آپ اپنے ملازمین کو کیسے اپنے ساتھ کام کرنے پر برقرار رکھتے ہیں اور نیے لوگوں کیسے تلاش کرتے ہیں اس طرح کی صورتحال میں ؟
- آپ کے کاروبار کے مختلف ڈیپارٹمنٹ کے درمیان تعلق کتنا موثر ہوتا ہے؟اس کے علاوہ دوسرے اثر انداز ہونے والے لوگوں یا اداروں کے ساتھ تعلق ؟ اور آپ سب کے درمیان معلومات کا تبادلہ کتنا موثر ہوتا ہے؟
- کیا آپ حسب ضرورت وسائل کو برقرار رکھتے ہیں ان غیر متوقع تبدیلیوں سے نمٹنے کے لیے؟
- آپ جب بحران کو نمٹنے میں مصروف تھے تو رویوں سے متعلق عناصر کیسے اثر انداز ہوے؟
- آپ کی مصنوعات کی فراہمی کے سلسلہ میں موجود دوسرے اداروں کی کامیابی نے آپ پر کیا اثر ڈالا؟
- آپ کے اپنے کاروبار کے کامیاب بچاؤ نے کیا پورے سلسلہ پر کوئی اثر ڈالا؟
- کیا آپ اپنے اہم کاروباری سپلائر اور صارفین پر یقین رکھتے ہیں؟آپ کے خیال میں وہ آپ پر یقین کرتے ہیں؟ آپ کے خیال میں یہ یقین کس کو کہتے ہیں؟
- کیا آپ اور آپ کے اعلی عہدوں پر فائز لوگ اپنے کاروباری سپلائر اور صارفین کے ساتھ اچھے تعلقات بنانے اور معلومات کے اشتراک کو ترجیح دیتے ہیں؟
- کیا آپ اپنی کاروباری ساخت اور ثقافت اپنے ساتھی کاروباری اداروں کی طرح بنانے کی کوشش کرتے ہیں؟

فراہمی کے سلسلہ کا نقطہ نظر:-

- کیا آپ کے سپلائر اور صارفین ان قدرتی آفات کی تیاری میں اور نمٹنے میں آپ کی مدد کرتے ہیں/کیسے کرتے ہیں ؟

- کیا آپ کا کوئی ایک نمایاں سپلائر/صارف ہے یا آپ ایک سے زیادہ سپپلائر/صارفین سے تعلق بنا کر رکھتے ہیں؟
- کیا آپ اپنے سپلائر کے سپلائر کو اور صارف کے صارف کو بھی جانتے ہیں؟ان سے بھی کاروباری تعلقات بناتے ہیں اور کیوں ؟
- آپ کے کاروبار کی سب سے اہم پراڈکٹ کیا ہے اور کیوں؟
- اس اہم پراڈکٹ کے لیے کونسے سپپلائر آپ کو مال فراہم کرتے ہیں؟ کہاں پر کاروبار کرتے ہیں یہ سپپلائر ؟ کیا یہ سپپلائر کسی اور کاروبار کو بھی مال فراہم کرتے ہیں؟
- کیا آپ کے سپلائر بھی آپس میں کاروباری تعلقات رکھتے ہیں؟آپ کا کیا کردار ہوتا ہے اس تعلق کو قائم کرنے میں؟ اور آپ کو اس کی وجہ سے کیا مشکلات پیش آتی ہیں؟
- کیا آپ قدرتی آفت سے نمٹنے کے لیا مال ذخیرہ کرتے ھو اور کہاں کرتے ہو اور کیسے کرتے ھو؟
- آپ کے مدمقابل کاروبار کرنے والے کون ہیں؟ کیا آپ ان سے بحران میں مدد لیتے ہیں یا کرتے ہیں ؟کوئی معلومات کا تبادلہ کرتے ہیں؟ مل کر کوئی منصوبہ بندی کرتے ہیں؟
- آپ بحران کے وقت صارفین کی ڈیمانڈ کا اندازہ کیسے لگاتے ہیں اور کیا آپ کے پاس اس ضرورت کو پورا کرنے کے صلاحیت ھوتی ہے؟
- کیا آپ اس قابل ہوتے ہیں کے نئی پروڈکٹ لے آیئں یا پہلی والی میں ھی کوئی ردوبدل کر لیں تاکہ صارفین کی ڈیمانڈ پوری کر سکیں؟
- کیا آپ کے صارف آپ کو مصنوعات کی ترسیل کے وقت میں لچک دیتے ہیں؟
- آپ کے خیال میں آپ ایک قابل اعتماد سپلائر یا صارف ہیں؟ اور کیوں؟
- کیا آپ اپنے کاروبار سے متعلق معلومات اپنے سپلائر اور صارف کے ساتھ بانٹتے ہیں؟ اور کب کب بانٹتے ہیں؟
- کیا گورمنٹ کے ادارے این جی او ، دوسرے مدد کرنے والے ادارے آپ کی مدد کرتے ہیں یا آپ ان کی مدد کرتے ہیں؟ اور کیسے کرتے ہیں؟
-

Appendix C

C.1 Vulnerabilities and Challenges Related to Natural Disasters

Vulnerabilities and Challenges
Challenges
Financial Challenges
High Markup Rates
Lack of Formal Financing Options
No Safety Tools
Political Problems
Incompetence Research Institutes
Lack of Coordination With Government
Lack of Stable Political System
Lack of Trust On Warning System
Poor Government Policies
Wrong Govt. Priorities
Social Challenges
Corruption
Hiding Information
Hiding Product Quality
Lack of Basic Education
Lack of Trust of NGOs
Lack of Trust of Research
Not Following Safety Procedures
Technical Challenges
Lack of Demand Prediction
Lack of Latest Forecasting Techniques
Poor Rain Predicting System
Vulnerabilities
Connectivity
Dependence on R1
Failed to be Exported
Lack of Access
Poor Transport
Network Related Vulnerabilities
Bulk Buying
Demand Supply Difference
Lack of Consistency in Demand and Supply
Lack of Demand Sharing with Suppliers
Lack of Modern Storage Place
Less Storage Space
Poor Packaging Standards
Poor Quality
Price Fluctuation

Short Shelf Life
Shortage of Supply
Speculation
Stagnant Water in Market
Supply Chain Partner Bankruptcy
Supply Variability
Physical Vulnerabilities
Damaged Bridges
Damaged Infrastructure
Damaged Roads
Faulty Equipment
Fuel Prices
Godowns Full of Water
Lack of Modern Technology to Preserve Food
Location of Land
No Electricity
Road Blockage
Social Vulnerabilities
Big Actors
Demolished Houses
Lack of Understanding
Transportation Rents

Appendix D:

D.1 Research Philosophy

It is widely accepted by researchers that philosophies have an important, and at times, uncertain relationship with research. Patton (2005) holds that good philosophy does not necessarily determine good research, nor does it help to make an effective researcher. However, it certainly can enhance the overall understanding of the social world. Traditionally, two opposing research philosophies are used in management research: positivism and phenomenology (Lincoln & Guba, 1985). Positivist relies on hypothesis testing from large data sets, whereas the phenomenological paradigm engages in interpreting and understanding the phenomenon. Positivism and phenomenology are two extreme ends of research; in between there could be other paradigms as well having elements of both these school of thoughts (Järvensivu & Törnroos, 2010; Lincoln & Guba, 1994; Lincoln, Guba, & Lynham, 2011). Creswell (2013) argues that while there are numerous classifications used to distinguish between different research paradigms, most of them share three elements. These three fundamental elements are ontology, epistemology and methodology (Lincoln & Guba, 1994).

- Ontology: is concerned with the nature and form of reality in the physical world
- Epistemology: is concerned about the nature of the relationship between the 'knower' and the 'known'
- Methodology: it deals with finding knowledge

Supply chain management studies uses many different research paradigms. In the next section, the research paradigm for this thesis is discussed. Based on the initial work of Lincoln and Guba (1994), who discussed five research paradigms, Järvensivu and Törnroos (2010) developed four research paradigms: naïve realism, critical realism, moderate constructionism and naïve relativism. For this thesis, moderate constructionism is the most relevant and has been used to shape this study on food supply chain resilience. The four main research paradigms are discussed below:

7.4.1 Naïve realism/Positivism:

The positivism paradigm, which is also called naïve realism (Järvensivu & Törnroos, 2010; Lincoln & Guba, 2000), focuses on law-like generalizations and causal relationships (Saunders

et al., 2011). This research approach is fully structured and repeatable, giving the same result when used again in natural sciences. Positivism is firmly based on the notion that knowledge is observed empirically in the form of testing hypotheses. The positivist researcher examines existing theory, deducts hypotheses and tests them on large representative cases. It argues these can be statistically analyzed for correlations (Bhattacherjee, 2012). These correlations and patterns are considered to reflect causes and effects. From these causes and effects, generalizations can be made. Ontologically, human actors are considered as only passive agents observing and recording events.

Positivism is the rights choice for closed business systems (Bhaskar, 2013). A closure of a system depends on either the complete isolation of a system from external influences or the influences should be constant. Internally, the objects, individuals or processes within the system should also be constant. These conditions might be true for certain elements like sales turnover or the total number of employees. However, networks or relationships within the organization do not fit in these conditions; these represent open systems as opposed to closed. Supply chain management studies, like this one, are not easily quantifiable. Reality and results are not clear. No matter how objective the researcher attempts to be, there will still be some elements that influence the research process and results. Therefore, this research paradigm is not suitable for this study.

7.4.2 Critical Realism/Post Positivism

Critical realism differs from naïve realism paradigm in the sense that it perceives the world in a less naïve, more critical, way (Järvensivu & Törnroos, 2010). According to Lincoln and Guba (2000), this school of thought is called the post-positivism paradigm. Although reality can be understood, it can only be so in probabilistic way. Critical realism affirms that the world investigated by science comprises of objects and these objects are structured and intransitive (Lewis, 1999). Structured means that these objects are irreducible to the events of experience; and intransitive means that these objects exist/act independently of their identification. Therefore, ontologically reality does exist independently away from researcher, but it is not merely objective reality as in the positivist paradigm. Research conducted under the critical realism can only specify the true or false probability of some hypotheses. Qualitative methods can be used; however modified manipulative or experimental studies are dominant methodological approaches in this paradigm (Lincoln & Guba, 2000).

Supply chain management related research can be conducted using this paradigm as there is a more critical understanding of the world compared to the positivist paradigm. However, for this thesis which wants to hear the experiences of respondents, a more open-ended approach is required. The researcher is not testing the hypothesis; instead opinions of respondents are required about the topic. Nevertheless, critical realism has been applied to much research on buyer-supplier or business network relationships. However, this study approach often fails to consider multiple perspectives of reality which different business networks have (Halinen & Törnroos, 2005). This research tends to lean towards a moderate constructionism paradigm.

7.4.3 Moderate Constructionism

Just like the critical realism, moderate constructionism (MC) lies in the middle of the continuum ranging from naïve realism (an extreme form of positivism) to naïve relativism (an extreme form of constructionism) (Lincoln & Guba, 2000). MC rejects the positivist argument of one universal truth. It defines truth as community based which can be extracted from empirical data. Järvensivu and Törnroos (2010) argue that both critical realism and MC acknowledge that research should be focused on finding the community restricted, interacting form of truth that is generated and validated through dialogue in different communities. Although ontological and epistemological grounds are the same for both these paradigms, moderate constructionism is more focused on multiple community formed knowledge bases. In contrast, critical realism is more concerned with finding the single universal reality. Community represents both research objects and the researcher who studies these objects. Reality can be reached through either or both.

To study supply chain or business networks, Johnsen (2011) suggests using the moderate constructionism approach. As this research is concerned with exploring the different resilient related concepts in food supply chains, MC is the philosophy which is dominant in this research.

7.4.4 Naïve Relativism

In general, the relativist or extreme form of the constructionism paradigm represents postmodern thought. Naïve realist believes a dualist and objectivist epistemology of knowledge, whereas relativist assumes truth is socially constructed. Naïve relativist considers objective observation of reality as meaningless (Lincoln & Guba, 2000). The naïve relativism

paradigm has been criticized for its over emphasizing the fact that all knowledge claims are equally good (Bhattacherjee, 2012; Creswell, 2013).

This is a possible way of analyzing supply chain management, especially when the researcher is not using any previous theory or framework. Grounded theory is a possible research strategy for this approach. As this research relies on different theories, and uses a conceptual framework, moderate constructionism has been used as well.

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