The Adaptation of Supply Chains to Climate Change

Andre Kreie

Submitted for the degree of Doctor of Philosophy

Heriot-Watt University

School of Management and Languages

August 2013

Abstract

Today, more and more organisations recognise that climate change is happening and have already begun to suffer from the impacts of this change. However, the predominant response to this challenge has been one of mitigation, not necessarily to protect companies and supply chains from the impacts of climate change, but rather to reduce the impact of business and logistics on the environment. In order to prepare organisations and their supply networks for the projected impacts, the concept of adaptation to climate change has recently attracted increasing attention amongst scientists and practitioners. As most research has been conducted in the public sector, this thesis aims to determine how supply networks in the private sector can adapt to climate change and its related risk factors.

The field research is designed as a single large case study and investigates a global coffee supply network. As the coffee industry is very sensitive to climate change it has already taken actions to make the supply network more resilient and can therefore offer valuable insights into the concept of adaptation to climate change. Multiple interviews were conducted and the information received was analysed using two developed *a priori* models concluded from literature.

This research contributes to the literature in supply chain risk management by adding supply chain climate risk (SCCR) as a new sub category of external supply chain risk and extends the literature in 'learning' by proposing a process model of network learning as a solution to enable supply networks to adapt to climate change. This thesis also offers a number of mechanisms to provide decision makers with practical recommendations that should be implemented throughout the coffee supply network.

Therefore, for the first time, this research addresses the contemporary problem of climate change by taking a supply network perspective and proposing a network learning process that enables an adaptation to the identified and location-specific climate risk. Besides its contribution to theory, this thesis is also highly relevant for practitioners as it offers clear managerial guidance of how the researched coffee supply network can become more resilient to climate change.

Acknowledgement

This thesis would have not been possible without the support and guidance of a number of people. Initially, I would like to thank both of my supervisors, Professor Alan McKinnon and Dr Christine Rutherford, for the opportunity to do this thesis. Their inspiring discussions and valuable input throughout the entire research process were a permanent encouragement to pursue this research. It has been a pleasure and honour to complete this thesis under their direction.

I am also thankful to Kerstin who made the contacts into the coffee industry, assisted during the interviews, and provided me with all the necessary background information needed to conduct this research. I would also thank Katharina, Christina, and Alexandra who helped me transcribing the interviews as well as all interviewees for their time and openness during the conversations. I further thank Steven for proof-reading the thesis. Special thanks go to Josef, Thomas, and the DAV-team who offered me the academic post and enabled me to further develop my academic skills.

Finally, I would like to thank my family and friends who greatly supported me over the time of this research. Their great encouragement and trust helped me to pursue my academic career. I particularly thank them for giving me the time to finish this work and for stimulating me in difficult times. I deeply value their friendship and much appreciate their patience and faith in me.

ACADEMIC REGISTRY

Research Thesis Submission

Name*:*	Andre Kreie		
School/PGI:	Management and Languages		
Version: *(i.e. First, Resubmission, Final)*	Final	Degree Sought (Award **and** Subject area)	PhD in Logistics and Supply Chain Management

Declaration

In accordance with the appropriate regulations I hereby submit my thesis and I declare that:

1) the thesis embodies the results of my own work and has been composed by myself
2) where appropriate, I have made acknowledgement of the work of others and have made reference to work carried out in collaboration with other persons
3) the thesis is the correct version of the thesis for submission and is the same version as any electronic versions submitted*.
4) my thesis for the award referred to, deposited in the Heriot-Watt University Library, should be made available for loan or photocopying and be available via the Institutional Repository, subject to such conditions as the Librarian may require
5) I understand that as a student of the University I am required to abide by the Regulations of the University and to conform to its discipline.

**Please note that it is the responsibility of the candidate to ensure that the correct version of the thesis is submitted.*

Signature of Candidate*:*		Date:	

Submission

Submitted By *(name in capitals):*	Andre Kreie
Signature of Individual Submitting:	
Date Submitted:	

For Completion in the Student Service Centre (SSC)

Received in the SSC by *(name in capitals):*			
1.1 Method of Submission *(Handed in to SSC; posted through internal/external mail):*			
1.2 E-thesis Submitted (mandatory for final theses)			
Signature:		Date:	

Table of contents

Tables

Figures

Chapter 1: Introduction

1.1 Research background

It is now widely accepted that climate change is occurring (IPCC 2007a). In this era of globalisation and the internationalisation of markets, many supply networks have become increasingly vulnerable to changing global environmental conditions. As Schneider (2011) clearly states, "*climate change poses a challenge that will test nature, human populations, as well as markets and economies*" (p. 53).

The predominant business response to this challenge has been one of mitigation, aiming to reduce the impact of economic activity on the environment. The Intergovernmental Panel on Climate Change (IPCC) (2007a) defines mitigation as *"technological change and substitution that reduce resource inputs and emissions per unit of output [...]. With respect to climate change, mitigation means implementing policies to reduce GHG emissions and enhance sinks".* IPCC (2007a) concludes that the principle of climate change mitigation is widely accepted by public bodies and private organisations. With a particular focus on logistics and supply chain management, McKinnon (2012) argues that companies have therefore come under mounting pressure to reduce the climate change impact of their operations. As a result, the wider concept of green logistics has emerged to improve environmental sustainability and to lessen the contribution of logistics activities to the causes of climate change. Most notably, research in this discipline has focused on cutting carbon emissions and developing models to calculate the carbon footprint of logistics operations. Despite these mitigation efforts in logistics and other industries, climate change continues to progress and its consequences for businesses are becoming more evident (Halldorsson and Kovacs, 2010). Halldorsson and Kovacs (2010) conclude that a changing environment will disrupt global supply chains more frequently and will impact on the financial performance and market position of an organisation. If it is accepted that climate change is happening it is clear that organisations will need to adapt their supply chains in response to a changing environment and in preparation for the projected impacts of climate-related risk.

More recently the concept of adaptation to climate change has received *"increased attention in the scientific and policy debate, and is seen as complementary to mitigation"* (de Bruin *et al.* 2009, p. 24). IPCC (2007b) defines adaptation to climate change *"as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation,*

and autonomous and planned adaptation". In response, many governments and public bodies have initiated research into their 'adaptive capacity' i.e. *"the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change"* (Smit *et al.* 2001, p. 881). Publications including 'Climate Change Risk Assessment' (Highway Agency 2011), 'Adapting to climate change in the Netherlands' (de Bruin *et al.* 2009), and 'Potential Impacts of Climate Change on U.S. Infrastructure' (Transport Research Board, TRB 2008), for example, investigate the adaptive capacities for certain regions and their infrastructures.

Despite pioneering research activities in the public sector, little effort has been made in the private sector to develop climate-related adaptive strategies. In order to address this research gap, this thesis seeks to explore approaches for adaptation that would help private companies and their supply networks to become more resilient to the current and projected impacts of climate change. As the risks associated with climate change extend beyond the boundaries of an individual organisation, this thesis takes a supply network perspective in order to address the interdependency between the businesses that are likely to be affected. For the first time, this research explores how a supply network, comprising private businesses, can adapt to climate change.

In order to contribute to the academic literature and offer practical advice to decision makers with responsibility for adaptation to climate change, an interdisciplinary research approach has been adopted in this research. To propose a solution to the problem of how supply networks might adapt to the impacts of climate change, various academic concepts are explored within the disciplines of 'supply chain management' (SCM), 'supply chain risk management' (SCRM), and 'learning and knowledge management' (LKM). This has involved a review of literature in four fields (Climate Science, SCM, SCRM, and LKM) and the development of multi-disciplinary frameworks. Given the lack of previous academic research on this topic, much of the research has been exploratory, combining deductive and inductive approaches. The main empirical work has involved an in-depth case study of the global coffee supply network, a network which will be highly vulnerable to the effects of climate change and within which management is already developing adaptation strategies.

In summary, this thesis addresses the very contemporary problem of climate change and adopts a new research perspective to examine the ways in which private organisations and their supply networks can adapt to climate-related risk. The thesis extends the academic literature on supply chain management, supply chain risk management and organisational

learning, and is also highly relevant for practitioners as it offers clear managerial guidance of how supply networks can become more resilient to climate change.

1.2 Research questions

The overall **research aim of this thesis is to determine how supply networks can adapt to climate change and its related risk factors**. This overall research aim addresses two more specific research objectives, each with research questions that the thesis seeks to answer:

Research objective 1: *To examine the current learning processes of organisations and supply networks relating to climate change risk.*

> ***Research question 1:*** *What type of learning enables companies and networks to adapt to climate change risk?*

Research objective 2: *To develop a process model of supply network learning applicable to climate change risk.*

> ***Research question 2:*** *What is the network learning process?*
>
> ***Research question 3:*** *What are the enabling principles and mechanisms that facilitate the network learning process?*

To answer the three research questions and achieve the research objectives and overall research aim, the following procedure was devised:

a) A comprehensive literature review covering the disciplines supply chain management; climate science; supply chain risk management; and knowledge management and learning, was carried out.
b) Integrating the reviewed literature, two *a priori* conceptual models on organisational and inter-organisational learning were developed to structure the field research. A single case study was carried out within a global supply network of 17 organisations. Primary data were collected from interviews with these organisations and analysed using the two *a priori* developed conceptual models.
c) Based on the findings from the field research, a process model for network learning was developed that builds on existing learning theory. It can help managers to better understand how network learning can be enabled to achieve the desired goal of supply network adaptation to climate change.
d) In the course of field work, a number of enablers and mechanisms of network learning were identified. In the context of this thesis 'Enablers' are defined as factors that

facilitate network learning, while 'mechanisms' are processes or procedures through which the factors influence key actors and decision-makers within the supply network. The role of enablers and mechanisms in the acquisition of knowledge about climate change in the coffee supply network were assessed.

1.3 Scope of the research

This research aims to explore how supply networks can adapt to climate change and the coffee supply network was selected to conduct the field research as it is already sensitive to the impacts of climate change. In total 17 organisations within the coffee supply network were studied to determine their adaptation capabilities and their intra- and inter-organisational learning activities. This thesis neither investigates the causes of climate change nor does it contribute to the research on future climate projections or mitigation efforts. The clear focus is on adaptation to climate risk, based on the assumption that climate change is occurring and that future projections are broadly correct. The limitations of this thesis will be discussed in more detail in the concluding chapter.

1.4 Thesis structure

The thesis is structured in three parts and comprises 12 chapters in total. As illustrated in Figure 1-1, each part is organised as follows:

Part A: Literature review

The literature review comprises four chapters (chapters 2 to 5). Chapter 2 reviews the literature on *supply chain management* with a particular focus on contemporary supply chain design in a rapidly changing business environment. In chapter 3, *climate change* is discussed as an important change factor in the PESTEL[1] framework. It discusses past trends, potential causes, future projections and the possible impacts of climate change on business and life on earth. Recognising that climate change is a major risk factor, chapter 4 explores *supply chain risk management* in the search for potential risk management strategies to cope with the projected climate impacts. As the development and implementation of these strategies requires organisational learning, chapter 5 reviews the literature on *knowledge management and learning* in order to find a process that might help supply networks to adapt to climate change.

[1] PESTEL = Political; Economical; Social; Technological; Environmental; and Legal

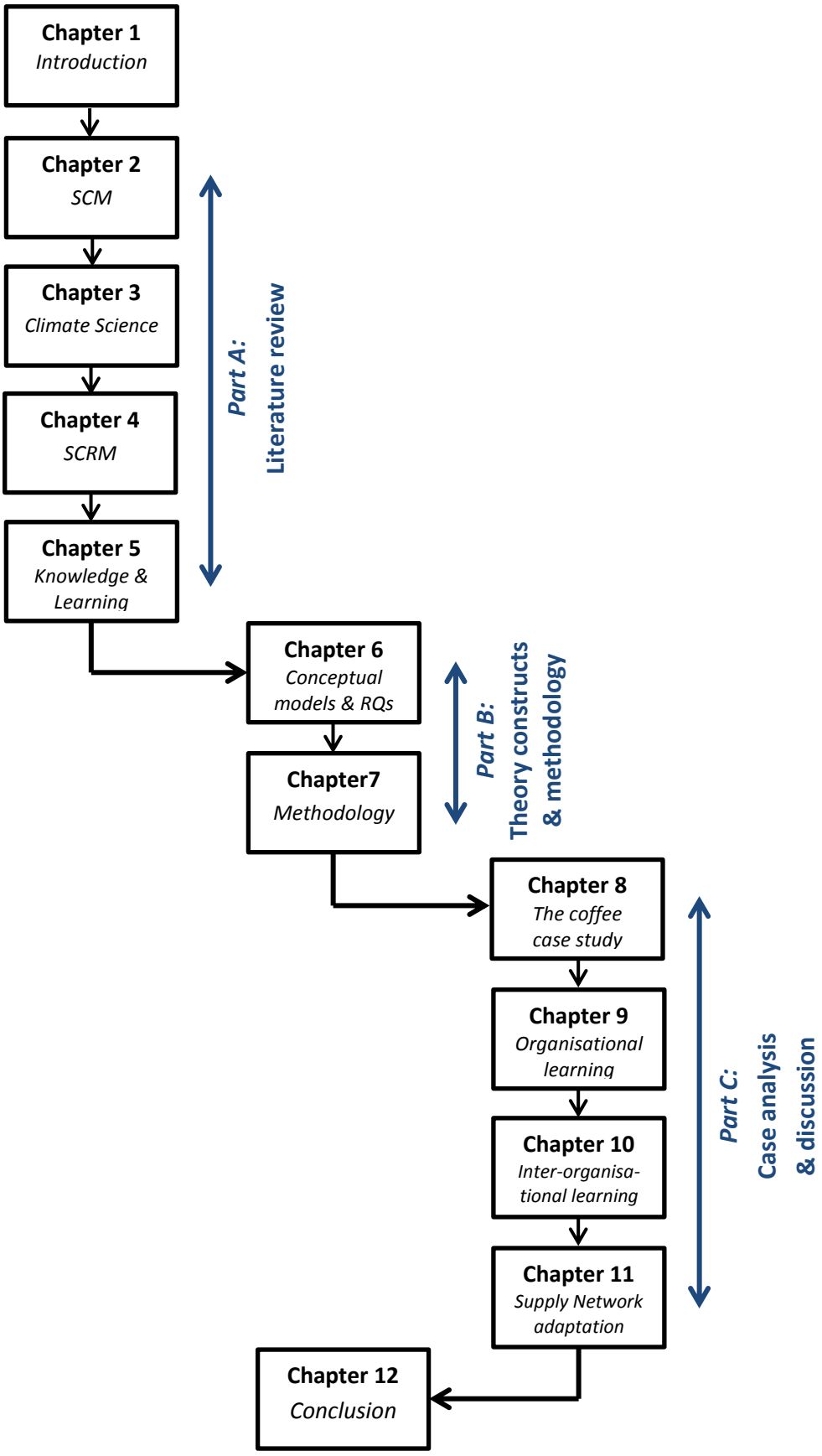


Figure 1-1: Thesis structure

Part B: Theory constructs & methodology

Integrating the different findings from the literature in the four fields, chapters 6 and 7 discuss the theory construct and appropriate methodology for the thesis. Chapter 6 builds on the literature review to develop two *a priori* conceptual models on learning to structure the field research and provides a framework for the subsequent analysis of the primary data. In chapter 7, the philosophical underpinnings of this thesis are determined and the single case study is presented as the chosen methodology to achieve the overall research aim.

Part C: Case analysis & discussion

In the third part of the thesis (part C), the findings of the field research are analysed. Chapter 8 gives a brief overview of the coffee supply network; chapters 9 and 10 analyse how the coffee business learns about climate change at organisational and inter-organisational levels. Chapter 11 integrates the findings from the previous two chapters and presents a model of network learning that describes and explains how the coffee supply network adapts to climate change. A number of enabling principles and mechanisms are presented that practitioners can implement to facilitate the proposed learning process and support adaptation to climate change. The final chapter 12 summarises the research and gives answers to the three research questions, thus meeting the overall research aim. It further discusses the limitations of the research and proposes directions for future research.

1.5 Summary

This thesis contributes to the academic literature on the adaptation of supply chains to climate change and provides practitioners with new insights into ways of collecting information about climate change and assimilating it into their supply chain risk models. The study adopts an interdisciplinary approach and focuses on the learning process at both organisational and supply network levels. The primary research has focused on the coffee supply network as it is already sensitive to the current impacts of climate change, has a reasonably complex global structure and proved a fertile source of empirical data. Sufficient information has been obtained from the literature and fieldwork to develop a process model for supply network learning that extends the existing theories, and provides practical guidelines for future managerial efforts to achieve adaptation.

Chapter 2: Supply chain management

2.1 Introduction

Supply chain management (SCM) is a relatively new research field. Fernie *et al.* (2010) mention that it is often traced back to the roots as initiated by Drucker's (1962) seminal work on improving distribution through efficiency and cost savings. They further argue that the key concepts in SCM include *"the value chain, resource-based theory of the firm, transaction cost economies and network theory"* (p. 897). In recognition of this perception, the position is taken that SCM aims to create customer value and that supply chains cannot be seen as a simplistic construct, but must be viewed as a complex and integrated (global) system. This research aims to reveal how organisations can pro-actively cope with the emerging challenge of climate change in order to maintain high customer value in a global and complex supply network.

2.2 Supply chains and supply chain management

In literature, there are many definitions for a supply chain (SC) though they have strong similarities. Christopher (1992, p. 15) argues that a *"supply chain is the network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that each produce value in the form of products and services in the hands of the ultimate consumer".* Lummus and Vokurka (1999, p.11) conclude that a supply chain can be stated as *"all the activities involved in delivering a product from raw material through to the customer including sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to the customer, and the information systems necessary to monitor all of these activities".* One of the latest definitions by the Supply Chain Council (2011) says, that a supply chain *"encompasses every effort involved in producing and delivering a final product or service, from the supplier's supplier to the customer's customer".* Drawing on the different definitions, each SC encompasses various agents, functions, and activities and differentiates from rival supply chains through the individual scope and distinct combination of the involved elements. Supply chains are not immutable constructs, but frequently reshape to the agents' needs when changes in the supply base or customer demand occur. The individual design and collaborative interaction of agents and functions reduce overall inventory investments, enable improved customer service, and help to build a competitive advantage for the entire supply network (Cooper and Ellram 1993). In a globalised world, agents are spread across continents and are often part of more than one supply chain.

For that reason, SCs are not a simplified and standardised construct, but have a network character with a certain level of complexity.

As a consequence of this complexity, supply chain management (SCM) has been developed to co-ordinate a ramified structure with a large number of interfaces between the involved agents across the network. Taking the pre-SCM perspective, the focus was predominately on the focal firm with little dependence on other agents. Little if any collaboration concerning risk and information sharing was carried out and the minimisation of firm costs as well as the individual business strategy were the key objectives (Cooper and Ellram 1993). Under the SCM construct, a different angle has emerged as not only a single firm, but also its related agents and external processes are within the scope. SCM represents a managerial approach with certain characteristics as summarized in Table 2-1 whereby the strategy is affected by increasing complexity through joined planning efforts across the agents, risk sharing and leadership qualities. Although the listed elements may not be complete and represent different levels of importance at different stages in the transportation and information process, they give a reasonable overview of the wide range of activities involved in supply chain management.

Characteristics	**Supply Chain**
Inventory Management Approach	Joined reduction in channel inventories
Total Cost Approach	Channel-wide cost efficiencies
Time Horizon	Long term
Amount of Information Sharing and Monitoring	As required for planning and monitoring processes
Amount of Coordination of Multiple Levels in the Channel	Multiple contacts between levels in firms and levels of channel
Breadth of Supplier Base	Small to increase coordination
Channel Leadership	Needed for coordination focus
Amount of sharing of Risks and Rewards	Risks and rewards shared over the long term
Compatibility of Corporate Philosophies	Compatible at least for key relationship
Joint Planning	On-going
Speed of Operations, Information and Inventory Flows	"DC" orientation (inventory velocity), interconnecting flows, JIT, Quick Response

Table 2-1: Characteristics of supply chain management
Source: Cooper and Ellram (1993)

Despite the presented attributes of SCM, Stock and Boyer (2009) note that SCM lacks a uniform agreed definition among academics as well as practitioners. From the reviewed literature, they identified 173 different definitions of SCM and concluded that researchers either concentrate on particular supply chain agents and activities (e.g. 1st tier supplier, etc…) or focus on material flows and inter-organisational collaboration. Moreover, some authors

include end-consumers in their definitions while others exclude them. The literature review by Stock and Boyer (2009) revealed that most SCM definitions do not consider all existing characteristics of a supply chain, but include only certain elements in their definitions. Gibson *et al.* (2005) contend that the number of varying definitions among academics and practitioners represents a normal evolution towards a consensus definition of SCM.

Table 2-2 summarises some of the often quoted academic definitions of supply chain management which again emphasise the focus on different elements and perspectives. However, the following features of SCM seem to recur and are included across most of the definitions:

- SCM takes an *end-to-end view* for all processes, agents and functions from the raw-material supplier to the customer and further to the recycling or disposal activities.
- SCM aims to *create value* to the *end-consumer* which is often the starting point from which a supply chain can be designed back to the raw material supplier.
- SCM has a *co-ordinating function* across all involved organisations along the supply chain to enable a smooth flow of goods and information. Christopher (2005) stresses that real competition is between supply chains and not between companies, which means that SCs need to measure and improve the overall performance level to achieve a competitive advantage.
- Whereas SCM is more strategic, it also comprises logistics activities to some extent at the operational level as discussed in the following section.

Author(s)	**Year**	SCM definition
CSCMP	2011	"Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies."
Stock and Boyer	2009, p. 706	"The management of a network of relationship within a firm and between interdependent organizations and business units consisting of material suppliers, purchasing, production, facilities, logistics, marketing, and related systems that facilitate the forward and reverse flow of materials, services, finances and information from the original producer to final customer with the benefits of adding value, maximizing profitability through efficiencies, and achieving customer satisfaction."

Svensson	2002a, p. 749	"SCM is a business philosophy that simultaneously should address the overall bi-directional dependencies of activities, actors, and resources on an operative, tactical, and strategic level between the points of consumption and origin in and between marketing channels in the marketplace."
Mentzer *et al.*	2001, p. 18	"[...] the systematic, strategic coordination of the traditional business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole."
Lummus *et al.*	2001, p. 429	"the management of all activities involved in delivering a product from a raw material through to the customer, including sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to the customer, and the information systems necessary to monitor all of these activities."
Christopher	1998, p. 18	"the management of upstream and downstream relationships with suppliers and customers in order to create enhanced value in the final market place at less cost to the supply chain as a whole."
Cooper *et al.*	1997, p. 2	"Supply chain management is the integration of business processes from end user through original suppliers that provides products, services and information that add value for customers."
Cooper and Ellram	1993, p. 13	"Supply Chain Management is an integrating philosophy to manage the total flow of a distribution channel from supplier to ultimate user."
Cavinato	1992, p. 285	"The supply chain consists of actively managed channels of procurement and distribution. It is the group of firms that add value along the product flow from original raw materials to final customer. It concentrates upon relational factors rather than transactional costs."

Table 2-2: Definitions of SCM

2.3 Supply chain management vs. logistics

Lummus *et al.* (2001) argue that it is a common notion that logistics involves the movement of physical goods from one location to another. Expanding logistics beyond merely physical distribution and including inbound as well as outbound movement of materials, the Council of Logistics Management (CLM) (1998) defines logistics as *"the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements".* The Council of Supply Chain M*anagement Professionals (CSCMP 2011) views logistics as one function or component of SCM and defines logistics management as *"that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverses flow and storage of goods, services and*

related information between the point of origin and the point of consumption in order to meet customers' requirements". This viewpoint is similar to Larson and Halldorsson's (2004) Unionist perception which treats logistics, and other business disciplines such as marketing and human resource planning, for example, as part of SCM. Accordingly, this position groups numerous management processes, of which one is logistics, as components of the SCM concept. As presented in Figure 2-1, Larson and Halldorsson (2004) provide three more conceptual perspectives on how SCM can be related to logistics. The *Traditionalist*-view positions SCM within logistics, i.e. SCM is only a part of logistics. *Relabeling* implies that logistics and its related activities are simply renamed by SCM, leading to the conclusion that both terms are used synonymously without any different meaning. Finally, the *Inter-sectionist* takes the view that SCM and logistics stand alone for themselves, but overlap in some functions and activities.

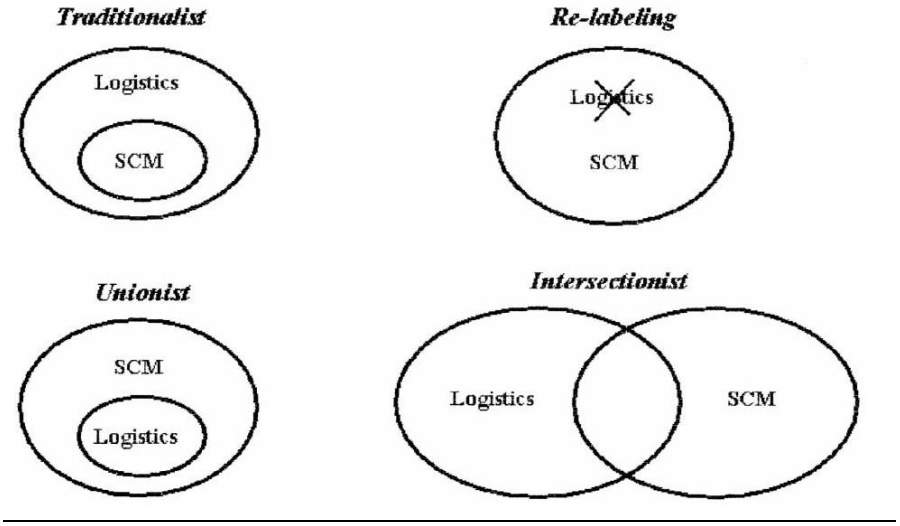


Figure 2-1: Perspectives on Logistics versus Supply Chain Mangagement
Source: Larson and Halldorsson (2004, p. 19)

Although Larson and Halldorsson (2004) state that all four perceptions exist among practitioners and academics, Stock and Boyer (2009) reveal from their review of SCM definitions, that researchers seem to conclude that SCM is somewhat more than logistics. In line with CSCMP (2011) and the previously presented key features of SCM, this thesis is based on the *Unionist* view that logistics is part of SCM. Also, Ballou (2007, p. 340) states that *"logistics is now being viewed as a subset of SCM".* Fernie *et al.* (2010) and Christopher (2005) point out that SCM is an extension of the logic of logistics and has been evolved from logistics in four key stages, each integrating more and more functions as well as different departments and organisations along the supply chain. Cooper *et al.* (1997) note that SCM differs from logistics by including components such as culture and attitude, power and leadership

structure, and inter-organisational management approaches. The following section discusses the evolution of SCM concepts and refers to the need of adaptation activities as part of the latest stage in the evolutionary process of SCM.

2.4 Evolution of supply chain concepts

One of the objectives of supply chain management is to ensure continuity in a firm's competitiveness and success (Mangan and Christopher 2005). Lummus and Vokurka (1999) argue that supply chain management can potentially improve a firm's competitiveness and Stank *et al.* (2005) take the position that at the strategic level SCM can create differential advantage for a company over its competitors by increasing the total value delivered to end-customers. Accordingly, Christopher (2005) concludes that 'supply chains' should nowadays be termed 'demand chains' as a contemporary chain is driven by markets and customers and not suppliers. Cox (1999) argues that the end consumer provides 100 per cent of the revenue to create the value chain in which the flow of revenue is absorbed by particular supply chain resources through 'value in exchange'. In this respect, modern supply chains apply the concept whereas customers pull their demand through the SC as opposed to manufacturers pushing their final products upstream to the end-consumer. As demand chains start with the customer and work their way back to the raw material supplier, the complex SC design must frequently be challenged as to whether it still addresses customers' needs under changed conditions. That is why one characteristic of SCM is the integration of the end-consumer into the overall SC strategy.

Against the background that supply chains aim to enable customer satisfaction, Christopher and Holweg (2011) discuss the shift in supply chain design from dynamic flexibility to structural flexibility as shown in Figure 2-2. They argue that SCM was originally invented in a period of relative stability and in the early stage had its focus on efficiency, i.e. being competitive through simplification of processes, cost reduction, visibility and so relatively low flexibility (*Efficient Supply Chain*). As a result, lean production concepts, controlling tools such as Six Sigma for example, and collaboration initiatives such as *Vendor Managed Inventory* (VMI) and *Collaborative Planning Forecasting and Replenishment* (CPFR) have been carried out to achieve as much control as possible over any variability along the SC. This concept of leanness means *"developing a value stream to eliminate all waste, including time, and to enable a level schedule"* (Mason-Jones *et al.* 2000, p. 54). Increased visibility and leanness result in lower costs and, in a world of relative stability, in increased profitability.

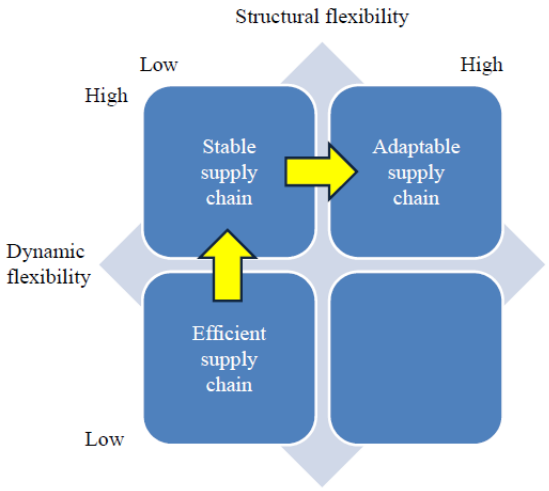


Figure 2-2: Moving from dynamic to structural flexibility
Source: Christopher and Holweg (2011, p. 69)

Yet, globalisation and open markets lead to increased product diversification, accelerated flow of information and so change customers' demand and buying habits. These transformations create the current understanding of SCM which aims to design stable SCs with reasonably high flexibility in dynamic markets (*Stable Supply Chain*). This so called dynamic flexibility (Christopher and Holweg 2011) can also address the concept of agile supply chains. Mason-Jones *et al.* (2000, p. 54) refer to agility *"as using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile market place".* Accordingly, agile supply chains work in less predictable environments where the demand for variety is high. Nowadays, supply chains often combine the advantages of both strategies and implement the "leagile" concept. It allows for customization of products and services in volatile markets and at the same time focuses on competitive input, e.g. low production and logistics costs through postponement, for example, to achieve high SC efficiency.

Although the concepts of lean SC (focus on efficiency) and agile SC (focus on customization and rapid response to unpredictable demand) have been well established, a fundamental re-thinking concerning the future design of SCs is required. Christopher and Holweg (2011) argue that organisations are currently facing major global changes and refer to these changes in the business environment as an 'era of turbulence'. Table 2-3 summarises some factors that might increase SC variability and impinge on supply chain performance.

Changing factor	Sample effects
Demand side	Shifts in consumer demand for products
Supply side	Hikes in steel, copper, and gold prices
Regulation	Shift in consumer perception towards climate change
Political	Opening of markets and growth in Asia, but also political rows and regional conflicts
Financial	Exchange rates, currency fluctuations, and availability of credit
Energy cost	The price for oil, gas and electricity, and the implications for transportation costs
Technology	Shifts in dominant designs, disruptive innovations

Table 2-3: Changing PESTEL factors in the era of turbulence
Source: Christopher and Holweg (2011, p. 69)

These changes extend the variability which originally emanated from supply and demand only and results in the agile concept no longer being able to achieve flexibility within the SC. In an era of turbulence, a wide range of rapidly changing factors in the PESTEL[2] business environment impact on the SC structure and therefore requires structural flexibility in response. Christopher and Holweg (2011 p. 73) define structural flexibility as a concept that *"enables a supply chain to adjust to shifts in its centre, or centres, of gravity. Supply chain design decisions are taken with the deliberate intention of building flexibility into the structure of the system".* This thesis takes on the concept of structural flexibility and investigates how supply chain structures can be designed in order to adapt to changes in the business environment in times of worldwide turbulence. As not all changing factors as listed in Table 2-3 can be addressed, the focus of this thesis is limited to climate change and how supply chains can respond to the projected impacts.

2.5 Supply chains as complex systems

The evolution of SCM concepts revealed that contemporary supply chains are highly ramified constructs with a large number of links between many suppliers, manufacturers, customers and other integrated agents. To coordinate all of the involved organisations along the supply chain, managers face a huge number of data to bear in mind when determining a competitive SC strategy. Increasing the number of links between involved organisations and spreading customers and suppliers all over the world, complexity in supply networks has consistently increased as a result of open markets. Hence, globalisation facilitates a supply chain's complexity and the enormous flow of information necessitates the taking of a holistic

[2] PESTEL = Political, Environmental, Social, Technological, Environmental, and Legal business environment

approach by SC managers without them going into operational detail (Greening 2010). For that reason, a key factor for success is a SC's capability to process any information on disruptive events, changes in the PESTEL environment and shifts in supply and demand through to each involved organisation. Achieving high visibility, efficient supply chains make use of technological tools for accurate forecasts and planning applications. Yet, flexibility is limited and often (mathematical) models try to map complex functions too simplistically. Although the contribution of these tools to a competitive supply chain is unquestioned, they may not be enough in an era of turbulence with interconnected processes that transcend a single company and are spread across the entire supply network (Nilsson and Darley 2006). For that reason, the principle of adaptation will become a rising priority in uncertain times to retain a competitive edge (Greening 2010).

Recently, academics have begun to question whether the linear approach of SCM is still sufficient as supply chains are nowadays *"more unpredictable, emergent and self-organising complex adaptive system"* (Greening 2010). As a complex adaptive system (CAS) is by definition multifaceted, beliefs such as linearity, stability, and homogeneity are improper to understand supply chains in an era of turbulence. Nilsson and Darley (2006, p. 1352) state that supply chains can be viewed as *"being of a complex and adaptive character based on perceptions of ongoing events in the local context".* The complexity emanates from the large number of agents with their own interests and individual learning culture of a changing environment which lead to continuous shifts in agents' minds. Figure 2-3 illustrates a complex supply network and how it is distinguished from a linear perspective of SCM. The network character implies that suppliers are often part of numerous supply chains and that the high number of links between partners up- and downstream the supply chain increases the complexity. For example, a supplier could be part of many rival supply chains meaning that many different business strategies must be taken into account. Moreover, adaptation planning for a particular supplier might be positive for one supply chain, but may damage another. This example emphasises the difficulties with adaptation of the entire supply network and underlines the importance of a leading organisation that co-ordinates and guides all adaptation activities across the system. As in literature, supply chains are referred to and understood as supply networks, and vice versa, this thesis uses both terms interchangeably, but always adheres to the complex nature and network character.

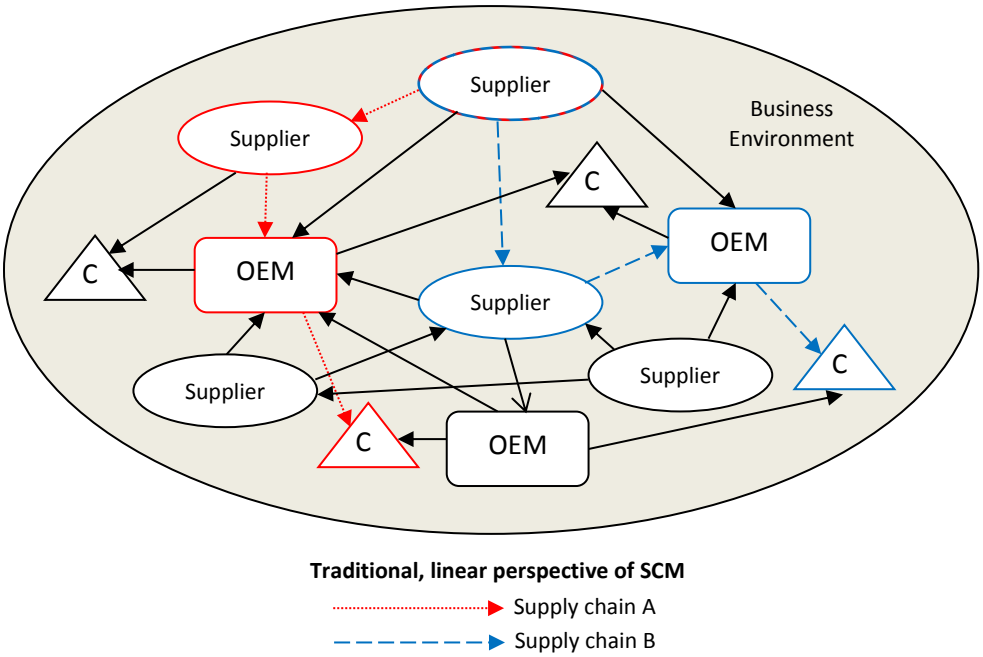


Figure 2-3: Complexity of a supply network

2.6 Summary

Despite being a relatively young discipline, SCM has quickly gained the attention of academics and practitioners. That is because SCM significantly contributes to a business' competitive advantage by integrating internal and external functions and processes into an overall concept that creates value for the consumer. However, the introduction into SCM revealed the lack of a common definition despite the fact that some key features of SCM such as end-to-end view, value creation and coordinating function, for example, appear to be included in most of the definitions. With reference to the distinguishing positions between logistics and SCM developed by Larson and Halldorsson (2004), this thesis takes the 'Unionist' position that views logistics as part of SCM. Accordingly, this research refers to strategic and tactical structures and decision making processes and does not primarily address operational logistics. With a clear focus on SCM, the evolutionary process that has been transforming efficient supply chains into adaptable supply chains thus providing consistently high customer service in a rapidly changing business environment has been accepted. As supply chains have nowadays become supply networks with numerous inter-linked entities in globalised markets, it can reasonably be argued that supply networks need to be adaptable in order to cope with the projected impacts of climate change. Arguing that supply networks that lack adaptation capabilities to climate change will lose competitive advantages, the next chapter presents climate change in more detail to better understand what supply networks actually need to adapt to.

Chapter 3: Climate science

3.1 Introduction

Over the last decade, climate scientists have gained increasing attention by the public as more confident projections of the consequences of climate change have put this topic on people's and businesses' agendas. However, detailed knowledge with high certainty and commonly agreed perceptions about climate change seems to be inexistent. This chapter aims to reveal the latest scientific findings that might explain the past observations of climate change, the possible causes for climate change, and the projected impacts as a result of climate change. Despite some contrary views among climate scientists, the purpose of this chapter is to provide a broad picture of what is likely to be expected from a changing environment caused by climate change. Based on these findings, organisations could then prepare strategies and activities that allow them to retain a resilient business and supply network.

3.2 Definition of key terms

Climate science is a growing field of research and involves multiple research areas. It investigates the causes for, and future projections of climate change as well as strategies and actions to mitigate the predicted negative consequences for humans and businesses. Therefore, it is essential that key terms are clearly defined before entering the discussions on how supply networks can adapt to a changing environment. To analyse how climate will presumably change over the next century this thesis is predominately based on the 4th assessment report on climate change by the IPCC (2007c). Due to its intergovernmental nature and bundling function of worldwide expertise, it is the most accepted and cited review of publications on climate change (Koetse and Rietveld 2009; WWF and Allianz 2009; Lenton *et al.* 2008; TRB 2008; Snover *et al.* 2007). To overcome the time-lag from the latest IPCC report in 2007, more recent investigations by the World Wide Fund for Nature (WWF) and the European Environment Agency (EEA) are also used as references.

3.2.1 Climate change

The World Meteorological Organization defines climate as *"the statistical description in terms of the mean and variability of relevant quantities over a period of time".* Accordingly, climate distinguishes from weather that refers to the state of the atmosphere with regard to meteorological conditions such as temperature, cloudiness, rainfall and wind at a specific place and time, e.g. temperature on 17th April 2015 in London (UKCIP 2010). Climate change can therefore be defined as *"change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or variability of its properties, and that for an extended period, typically decades or longer"* (IPCC 2007c, p. 78). Classically, a 30-year period is

used to determine what is considered as normal climate and how it may vary over time (WMO 2010).

On this basis, climate change is unequivocal (IPCC 2007c; NOAA 2009). The conclusion is based on a range of different parameters observed such as increase of mean air- and oceanic temperature, acceleration of ice melt and rise in mean sea-level. For example, the global average surface temperature rose by 0.6°C for the 100-year linear trend from 1901 to 2000. However, the linear warming trend over 50 years from 1956 to 2005 is nearly twice that for the 100 years from 1906 to 2005 which may turn the quite linear temperature rise to a more exponential curve in the future. Similar significant changes were observed for sea level rise and other variables such as precipitations, wind characteristics as well as extreme events such as droughts and storm surges (IPCC 2007c). Despite the common conclusion among climate scientists on the fact that climate will change significantly; the forecasted climate trend over the next century is highly uncertain (IPCC 2007c).

3.2.2 Future projections of climate change

In order to display the current and future climate scenarios, climate models help to simulate the varying climate complexity by combining a spectrum of different quantified components from physical, biological, and chemical processes in spatial dimensions at the global and local scale (IPCC 2007c). Despite their integration into scientific research and widespread acceptance, climate models are limited to their accuracy due to a long time-horizon to predict and due to the complex interaction between the numerous components of the climate system (Schuchardt & Wittig 2010). For that reason, more commonly researchers refer to climate scenarios that integrate the modelling techniques, but also aim to forecast the conditions under which people live by emphasising assumptions concerning the future socioeconomic and technological development, for example (IPCC 2007c). Climate scenarios therefore consider two main issues[3].

First, scenarios demonstrate alternative ideas of how the future might be and how various driving forces such as demographic development, socio-economic development and technological change may influence future GHG emissions. Depending on the combination of the different driving factors, different future climate trends are forecasted. In total, four different narrative storylines A1, A2, B1 and B2 were developed by the Special Report on

[3] Unless otherwise specified, any information and number provided represents the global mean value. Also, no prospective policies on mitigation of climate change are regarded in the forecasts.

Emissions Scenarios (SRES) in 2000 to *"describe consistently the relationships between emission driving forces and their evolution and add context for the scenario quantification. For each storyline several different scenarios were developed using different modelling approaches to examine the range of outcomes arising from a range of models that use similar assumptions about driving forces"* (IPCC 2000, p. 3). As a result six different scenarios [A1B, A1F1, A1T, A2, B1 and B2] were agreed as representatives of integrated assessment frameworks in the literature. Table-3-1 summarises the key criteria of the scenarios as described in the IPCC report and highlights their wide range of considered future projections.

Development by 2100	**A1**	**A2**	**B1**	**B2**
Population growth	Low	High	Low	medium
World GDP	High	low/medium	medium	medium
Primary energy source	fossil & non-fossil	fossil	non-fossil	non-fossil
Resulting GHG-emissions	high increase [A1F1] medium increase [A1B] low decrease [A1T]	high increase	low decrease	medium increase

Table-3-1: Important criteria in the selected SRES scenarios

Second, climate scenario also display the future trend of 'Greenhouse Gas Emissions' (GHG), which have mostly been identified as key driver of climate change. However, some researchers argue that other factors than greenhouse gases are the driving forces of global climate change. Some researches (Svensmark and Friis-Christensen 2007; Scafetta and West 2007; Berner and Streif 2004) take the position that the sun contributes significantly to climate change. Other research by Veizer (2005) argues that cosmic ray flux (CRF) which consists of energetic particles that hit the atmosphere and potentially generate cloud condensation nuclei is a key driver for climate change. Finally, some researchers (e.g. Akasofu 2010, etc…) say, that the observed climate changes are only part of natural climate fluctuations over millions of years and that they are not caused by any particular driving force. These alternative perceptions to the IPCC report are not generally declined, but are not considered in this thesis as they represent positions with no consensus among climate scientists. For that reason, the position by the IPCC (2007c) is applied as a large majority of climate scientists agree with the finding that human addition of CO_2 and other greenhouse gases into the atmosphere have contributed significantly to the observed global warming (Brown *et al.* 2007).

Having the focus on the greenhouse gas effect, clarification is required as this effect is basically a very good thing. Greenhouse gases trap heat radiated from the earth's surface and prevent it from escaping into space. Without GHG emissions in the atmosphere, the world would be uninhabitable due to freezing surface temperatures (Walker and King 2008). Observations over the previous decades showed that more and more heat has been trapped in the atmosphere causing increased global warming. Although oxygen and nitrogen make up more than 99 per cent of the atmosphere, they make not much difference to the future trend of temperatures. Hence, the remaining gases predominantly count to explain the natural greenhouse effect (Walter and King 2008). According to UNFCCC (2010), six direct groups of greenhouse gases (Carbon Dioxide, Methane, Nitrous Oxide, Hydrofluorocarbons, Perfluorocarbons and Sulphur Hexafluoride) have been classified and are consistently referred to in worldwide reports and analyses. The concentration of these GHGs in the atmosphere has been increasing in recent decades which implies a positive radiative forcing, i.e. a tendency to warm the climate system (TRB 2008). Typically, all GHGs are expressed as carbon dioxide equivalents (CO_2-e) to allow for a comparison concerning their global warming potential, respectively, which ranges from 1 for carbon dioxide (CO_2) to 22,800 for hexafluoride (SF_6). The massive increase of carbon dioxide emissions is a result of human activity (Walter and King 2008). Burning fossil fuels such as oil, coal and natural gas is key to climate change as it releases a high amount of CO_2 in a very short period of time. For that reason, the trend of climate conditions is closely linked to the emission of carbon dioxide which among the GHGs is currently the most significant. Although all GHGs account for only approximately 0.04 per cent of all gases in the atmosphere, any climate forecast needs to consider the possible future trend of GHG emissions under different economic, social and technology scenarios (Walter and King 2008). Yet, despite the consideration of many different driving forces, feasible projections of the future trend of GHGs cannot be used as precise forecasts (Schuchard and Wittig 2010).

The overview in Figure 3-1 clearly indicates the converse trends of GHG emissions under different scenario conditions. While the A2 (red line) and B1 (blue line) scenarios stand for the maximum and minimum amount of GHG emitted by 2100, the A1B scenario (green line) contains medium GHG concentrations. Apart from the range of GHG emissions provided by the SRES scenarios, recent simulations by post-SRES scenarios indicate either a much stronger or much weaker trend of GHG emissions. In a worst case scenario, the amount of GHG emitted could achieve a level which is almost five times higher than today already by 2070 and therefore points to a very strong exponential emission curve. The importance of the future emission curve lays in its influence on the climate development. Hence, under the A1F1 and A2 scenarios more radical and intense changes in climate are expected while the future under the

B1 scenario implies only a moderate climate change over the next century. Besides the possible future climate pictures drawn by the IPCC, recent investigations by other non-governmental Organisations (NGO) such as WWF (WWF and Allianz 2009) assume a more rapid growth of GHG emissions, i.e. a trend which is rather related to the maximum post-SRES curve (upper dashed line in Figure 3-1).

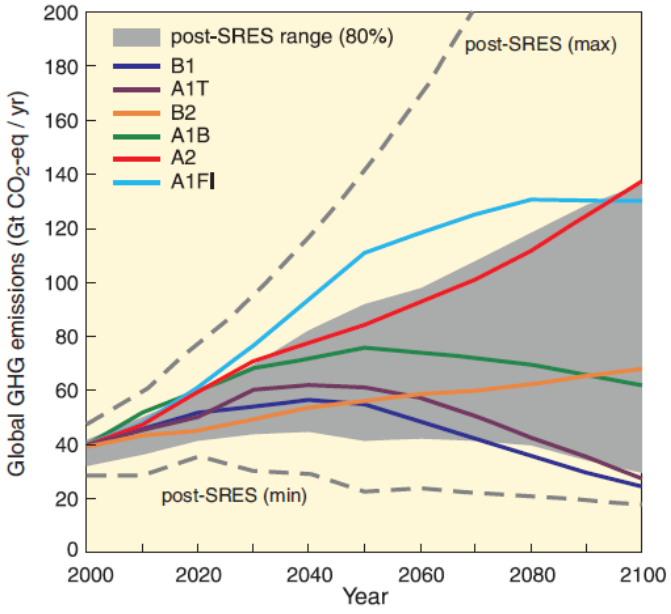


Figure 3-1: Scenarios for GHG emissions from 2000 to 2100 in the absence of additional climate policies
Source: IPCC (2007c, p. 44)

3.2.3 Limitations of climate models and scenarios

With respect to the future projection of climate change, many uncertainties exist. Particularly, climate models which are based upon different circumstances in the introduced scenarios can be criticised on a number of points. First, the large number of model approaches and simulations result in a wide range of forecasted climate conditions which often provide conflicting predictions. As a result, also extreme climate scenarios are simulated, but underlie large uncertainties and therefore are unlikely to occur (Koetse and Rietveld 2009). Second, the long period of a century to consider in climate models lead to inaccuracy of forecasts. Of particular interest and concern in this respect is the incidence of the so called *tipping point* which is *"a critical point (in forcing and a feature of the system) at which a transition is triggered for a component of the Earth's system that can be switched under particular conditions into a quantitatively different state by a small perturbation"* (WWF and Allianz 2009, p. 3). At this particular point in time intense climate changes cannot be turned back as environmental effects become unmanageable and strongly accelerate their impacts on human life. An exampling tipping point is the melting of the Permafrost in Russia which would lead to

a massive release of methane with a much higher global warming potential than carbon dioxide.

Scientists suggest that some tipping points may be reached if the global mean surface temperature exceeds 2°C above pre-industrial levels. According to Stern (2007) this temperature could only be achieved if GHG emissions in the atmosphere stabilised at a level of 450 parts per million (ppm), which is the equivalent to 0.045 percent. However, this 2°C threshold is not entirely certain (WWF and Allianz 2009) and can therefore not be included in simulation models. In fact, the latest research points out that current pledges and loopholes in global legislation are likely to result in exceeding 1.5°C (or 350 ppm CO_2-eq.) in temperature rise. Even if nations agree to halve emissions by 2050 there is still a 50 per cent chance that the climate will exceed the 2°C (450 ppm CO_2-eq.) warming threshold. Moreover, the research by Rogelj *et al.* (2010) revealed that if the current rate of GHG emissions is extrapolated into the future, there is a greater than 50 per cent chance that global warming will exceed 3°C by 2100.

Despite these two limitations (varying results of simulations and long time horizon), the approaches of climate modelling and emission scenarios are reasonably well developed and accordingly are used as reference in this dissertation as they represent the current state-of-the-art knowledge. For this thesis, it is therefore assumed that the general conclusion on climate change, i.e. rising temperatures and the resulting impacts as predicted by most climate researchers around the globe, is accurate to the provided level of certainty.

3.2.4 Likely impacts of climate change

This section analysis how the projected future trends of GHG emissions impact on businesses, humans, and the environment. Figure 3-2 summarises the relationship between the amount of emitted GHG and the corresponding change in surface temperature. For example, under the B1 and A1T scenarios only approximately 400ppm CO_2-equivalents are likely to be emitted resulting in a moderate temperature rise of 1 to 3°C. In opposite, the A2 and A1F1 scenarios may lead to an emission level of about 750ppm CO_2-equivalents with a corresponding temperature rise of up to 6.4°C or more.

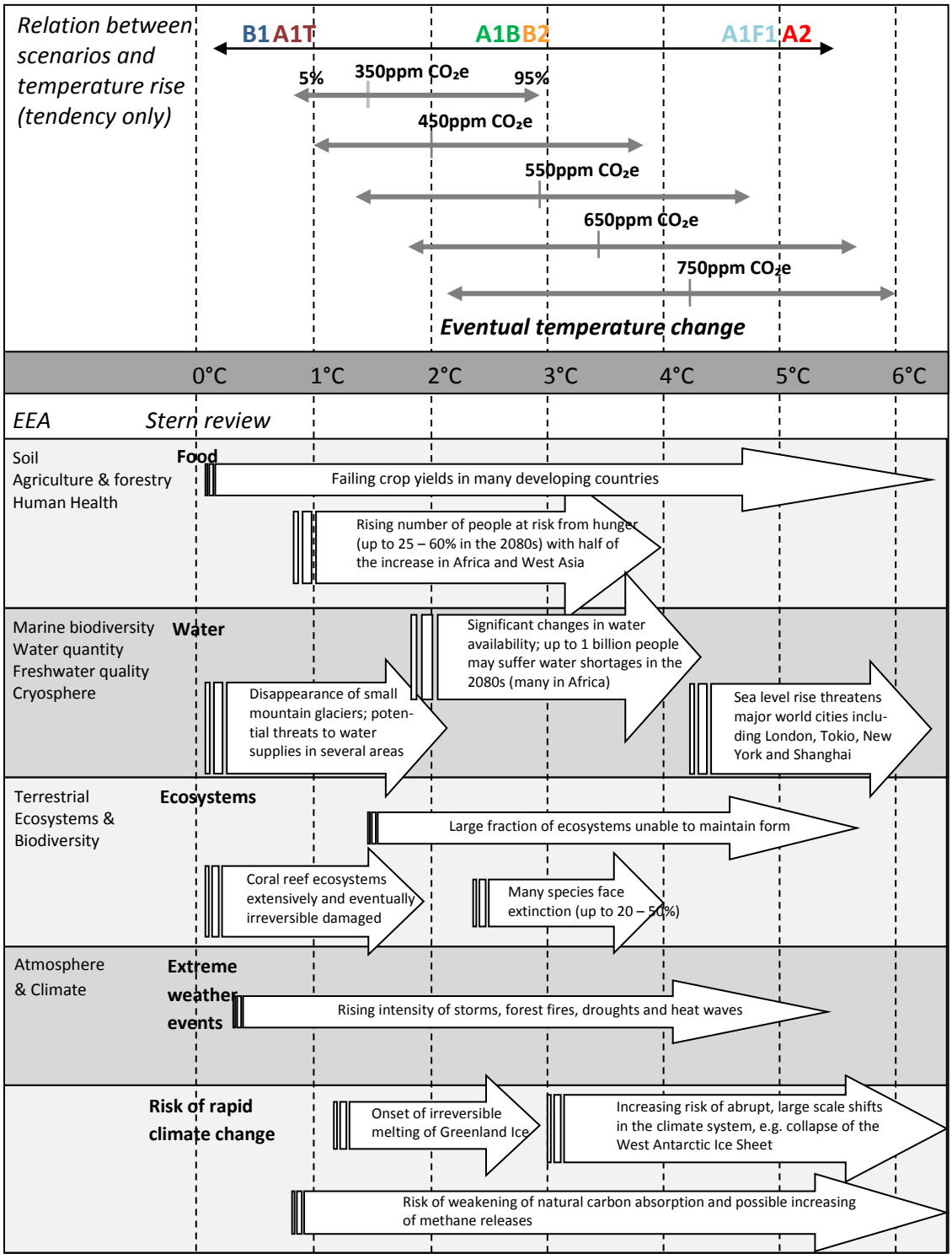


Table 3-2: Types of possible impacts if GHG emissions increase and temperature rise[5]
Source: adapted from Stern (2007) and IPCC (2007c)

[5] Results are relative to pre-industrial age. 5 to 95% confidence interval is shown with 50% probability indicated as upright grey bar.

Dependent on the average level of warming, the changing climate has significant impacts on various natural and social systems. The European Environment Agency (EEA 2008) grouped different indicators into nine categories which are likely to be affected by climate change: *Atmosphere and climate; Cryosphere*[6]*; Marine biodiversity and ecosystems; Water quantity; Freshwater quality and biodiversity; Terrestrial ecosystems and biodiversity; Soil; Agriculture and forestry* as well as *Human health*. A further classification is provided by Stern (2007) who established five categories named *Food; Water; Ecosystems; Extreme Weather Events*, and *Risk of further much more rapid climate change*. As shown in Figure 3-2, the number and intensity of potential threats in each category accelerates with rising temperatures. All categories are subject to more radical changes under the A1F1 and A2 scenarios whereas the A1T and B1 scenarios cause minor adjustments of current observations. For simplification reasons, the determined five categories by Stern (2007) are used for a further detailed analysis.

3.2.4.1 Food

Highlighting the possible impacts of climate change and rising temperatures, people are predominately put at risk of hunger caused by sharp declines in crop yields in some regions around the world. This effect is reinforced by an altered habitat of soil bio data which controls numerous ecosystem processes and influences the structure of flora and fauna (EEA 2008). Although in some regions (e.g. Europe, etc…) crop yields may positively benefit from longer growing seasons, particularly Africa is intensively harmed meaning that an additional of 150 to 550 million people may suffer from hunger already if the average surface temperature rises by 3°C. Moreover, Africa will also be affected by climate-related increases of diseases such as malaria and malnutrition which could make millions of people die (Stern 2007).

3.2.4.2 Water

The category *Wate*r is highly affected by changes in climate conditions with serious physical and monetary consequences for people. Hinkel and Klein (2009) and Arnell (2004) argue that particularly, sea-level rise, loss of wetlands and contamination or shortage of water are expected to be the key negative consequences. Concerning sea-level rise, Table 3-3 reflects the dependency on temperature rise and summarises the best estimated values according to IPCC (2007c), Rahmstorf (2007) and Pfeffer *et al.* (2008). All projections on sea-level rise are global average values despite the fact that sea-level rise is not anticipated to be uniform around the world. Based upon the respective scenario, temperature is likely to change within a range

[6] Cryosphere is the frozen water part of the Earth system with two major components: land ice and sea ice.

between 1.1°C and 6.4°C over this century. Accordingly, global sea-level is likely to rise between 0.18 and 2.00 meters in average. However, the IPCC AR4 disregards possible tipping points in its calculation due to their high level of uncertainty. Recent investigations go far beyond the IPCC predictions and expect global sea-level to rise much more severe over this century as likely tipping points such as rapid melt of polar ice sheets (Greenland and West Antarctica) is included in the new estimates. Concluding on the different research results on sea-level rise, currently no consensus on the upper bound of global sea-level rise exists among climate scientists.

Scenario	**Temperature change (°C at 2090-2099 relative to 1980-1999)**		**Sea-level rise (m at 2090-2099 relative to 1980-1999)**	**Sea level rise (m by 2100 relative to 1990)**	**Sea level rise (m by 2100 relative to 1990**
	Best estimate	Likely range	Model-based range by IPCC. Excluding future rapid dynamical changes in ice flow	Model-based range by Rahmstorf (2007) [incl. statistical error; one SD]	Unrelated to IPCC scenarios (Pfeffer 2008)
B1	1.8	1.1 – 2.9	0.18 – 0.38	0.55 – 1.25 [0.50 – 1.40]	0.80 -2.00
B2	2.4	1.4 – 3.8	0.20 – 0.43		
A2	3.4	2.0 – 5.4	0.23 – 0.51		
A1F1	4.0	2.4 – 6.4	0.26 – 0.59		

Table 3-3: Projected global average surface temperature warming and sea-level rise at the end of the 21st century
Source: adapted from IPCC (2007c), Rahmstorf (2007), and Pfeffer *et al.* (2008)

3.2.4.3 Ecosystems

The world's ecosystem will be affected a) directly by climate change, and b) indirectly by species-specific responses, i.e. altered biodiversity. The most observed changes will be the damages to reefs and rainforests. Although coral reefs may not completely be extinct they will suffer serious hurts from rising temperatures and some may die or strongly bleach. For example, large parts of the Great Barrier Reef have already been lost or are irreversibly being damaged each year. A similar development is likely for rainforests, particularly for the important Amazonian rainforest (Stern 2007 and EEA 2008). Concerning biodiversity, some species are expected to significantly diminish or face extinction. Despite the species' capabilities to adapt to a changing environment, particularly mountain plants and species in fragmented landscapes are supposed to be extinct as a result of climate change (EEA 2008).

3.2.4.4 Extreme weather events

Over the next century, people are likely to be seriously affected by an increased frequency of river flooding as well as heat waves and droughts (EEA 2008). Also storm surges in coastal areas are expected to be more intense. Hurricanes are forecasted not to increase in number, but to get stronger and last longer resulting in a possible doubling of hurricane damage costs in the United States, for example. The future trend of heavy rain falls (monsoons) remains inconsistent as they are likely to develop non-uniformly, i.e. some regions may become significantly drier and some regions may become extensively wetter (IPCC 2007c, Walker and King 2008).

3.2.4.5 Risk of more rapid change

The risk of more rapid climate change is strongly correlated to climate tipping elements (e.g. melting of ice sheets, etc…) and the selected GHG emission scenario. Particularly, the possible release of massive amounts of methane from Permafrost is likely to have a negative impact on the future climate. Due to its much higher GWP in comparison to CO_2 (Stern 2007), methane would then be ranked first place among GHGs to influence climate change. The likelihood of tipping elements rises with increasing global surface temperatures.

3.2.5 Regional differences of climate change

As all information is at the global scale so far and climate is projected to change non-uniformly around the world, regional differences are discussed in this section as significant deviations from the global mean are predicted for some areas. Up to now, local and regional characteristics such as the Wadden Sea have often been disregarded in the analysis of climate change. Based on a higher resolution of climate models, national and regional simulations of the future climate provide more accurate results. For that reason, IPCC (2007c) and The European Environment Agency (EEA 2008) have produced specific analyses concerning climate change for continental and national areas such as Europe and the UK, for example. However, due to the relative high protection standards in the European Union and other developed countries (< 1 in 1000 year flood level) the capabilities to adapt to climate change are relatively high and the impacts of climate change on humans and business are low or moderate (Nicholls and Tol 2006). In turn, many other regions, particularly in Asia, are more likely to suffer massively from climate change, mostly from flooding (Hinkel and Klein 2009). In conclusion, any geographic area is differently affected by changing climate conditions. For that reason, a detailed analysis of how climate change impacts locally on the supply network is always necessary when discussing SC adaptation strategies.

3.3 Summary

The large field of climate change has recently become more and more important in academics and public. It aroused companies' interests as numerous research activities and articles in press revealed the latest information on a changing climate which will impact human and business activities in the future. Observations over the last century provided evidence of global warming, (e.g. increasing temperatures and sea-levels, etc…) and entire ecological systems have been altered. One of the key causes of climate change is the increase in GHG concentrations in the atmosphere, in particular CO_2. Increasing concentrations of greenhouse gases in the atmosphere prevented heat radiated from the earth from escaping into space (positive radiative forcing). Based on different driving forces such as global energy-mix, technology and population growth, different future scenarios (SRES-scenarios) have been determined and include varying trends of GHG emissions. Depending on the scenario, more modest or more severe impacts of climate change have been predicted. Table 3-4 summarises these possible impacts and groups them into the five climate factors provided by Stern (2007). In order to analyse and mitigate the potential hazards of these five climate factors for supply networks, the next chapter looks into the literature in risk management and supply chain risk management.

Climate factors Stern (2007)	EEA (2008)	**Possible changes by 2100**	**Source**
Water	Marine biodiversity Water quantity Freshwater quality Cryosphere	Sea-level rise between 0.18 – 1.40m (locally in Germany up to 2.16m). Significant reduction in fresh water availability.	IPCC (2007c) Rahmstorf (2007) Bioconsult (2010)
Food	Agriculture & forestry Soil Human Health	Major declines in crop yields. Collapse of food supplies in some regions (e.g. Africa, etc…).	EEA (2008) Stern (2007)
Ecosystems	Terrestrial ecosystems & biodiversity	Irreversible (partial) damage of coral reefs and rainforests. Extinction of many species.	EEA (2008) Stern (2007)
Extreme weather events	Atmosphere & climate	Rising intensity of storms, floods and forest fires. Increased financial risk is likely to develop non-linearly.	Stern (2007) WWF and Allianz (2009)
Rapid climate change		Non-linear rate of change may have catastrophic affect.	Stern (2007) WWF and Allianz (2009)

Table 3-4: Impact of global warming on identified climate factors

Chapter 4: Risk management

4.1 Introduction

In times of globalisation and quickly changing business environments, risk management is essential for organisations in order to rapidly detect potential threats to their businesses and to develop appropriate mitigation strategies in response. This chapter introduces the concept of risk management and supply chain risk management (SCRM), and identifies climate change as newly rising risk to which companies and supply networks must develop responding strategies. In particular, SCRM is presented as appropriate approach to identify, analyse and mitigate the likely impacts of climate change on global supply networks. The chapter concludes on an overview framework that identifies five supply chain climate risk factors that impact on supply chains either directly or indirectly. In response, the concept of the triple-A supply chain is presented to design a resilient supply network under a changing environment, with a particular focus on the 'adaptation' element.

4.2 Risk

A definition of risk often depends on the context or perspective, e.g. financial or social context (Spekman and Davis 2004), but can be defined on a general level as *"the probability of variance in an expected outcome"* (p. 416). From a decision theory perspective, risk is understood as *"variation in the distribution of possible outcomes, their likelihoods and their values"* (March and Shapira 1987, p. 1404). Rao and Goldsby (2009) interpret risk as the exposure to a premise of which the outcome is uncertain. A more scientific definition is provided by the Royal Society (1992) which views risk as *"the probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge. As a probability in the sense of statistical theory, risk obeys all the formal laws if combining probabilities"*. According to Mitchell (1995, p. 116) this definition of risk, R, expressed as formula, assesses the probability of the loss, P(loss), and the significance of the loss, I(loss), for an event n: $R_n = P(loss_n) \times I(loss_n)$.

However, Yates and Stone (1992) argue that any risk must also imply some level of uncertainty about the outcomes; otherwise there would be no risk if the probability of an outcome is known. Although the term uncertainty is often used as a synonym for risk, their definitions differ. Knight (1921) quoted by Peck (2007, p. 229) provides an initial distinction between risk and uncertainty: *"if you don't know [...] for sure what will happen, but you know the odds, that's risk, and if you even don't know the odds, that's uncertainty"*. Yet, some researchers such as Adams (2000), for example, argue that a formal treatment of risk and uncertainty requires some knowledge of the odds. Hence, Ritchie and Brindley (2007, p. 306) state, that

uncertainty is *"a special case of the risk construct, in which there is insufficient information, knowledge or understanding to enable the decision taker to identify all of the potential outcomes, their consequences or likelihood of occurrence".* Goodwin and Wright (2009) point out that decision makers often lack a neutral attitude toward risk and are unable to estimate probabilities for the outcomes. For that reason, decisions are often made under uncertainty where the probability of an outcome is unknown rather than being based on a risk analysis which implies a detailed knowledge of the outcomes and their probabilities, respectively.

In game theory, risk is usually calculated using the relationship defined by Mitchell (1995). Yet, Harland *et al.* (2003) argue that the simplified formula seems to be improper to some disciplines as it does neither cover all business aspects which contain a multi-perspective nor does it indicate managers' reflections and behaviours on risk. Moreover, this formula approach ignores other decision criteria and may ignore the decision maker's attitude toward risk. For example, social norms which often have a significant influence on risk understanding and management are excluded. Addressing the problem of objectifying risk, the Royal Society (1983) distinguishes between 'objective risk' which is applied by experts to determine quantitative scientific means, and 'perceived risk' as imprecise and unreliable perceptions of laity. In contrast to this definition, modern approaches do not make this difference. In managerial disciplines, social scientists argue that risk is not discrete and particularly when people are involved inherently resistant to objective measurements. In other words, people have subjective perceptions of risk and accordingly modify their behaviour to the individually expected exposures (Peck 2006). Therefore, human behaviour results in unquantifiable changes in exposure in contrast to financial risk, which is able to determine the ultimate odds (Adams 2000). In this context, decision makers often consider only selected elements of the introduced risk equation and do not include the total range of possible outcomes. Zsidisin (2003) notes, that a further facet of uncertainty refers to executives and their lack of understanding about existing loss categories. In managerial minds, risk is rather associated with potentially negative outcomes. Harland *et al.* (2003) define risk as a result from danger, loss, injury or any other undesired consequence, which in fact implies only a negative meaning. Taking on this different understanding of risk, March and Shapira (1987, p. 1407) identify a persistent tension *"between 'risk' as a measure on the distribution of possible outcomes from a choice and 'risk' as a danger or hazard".* This dissertation regards both, negative and positive risk outcomes and their probabilities, respectively.

4.3 Supply chain risk (SCR)

Juttner *et al.* (2003) define supply chain risk as anything that presents a risk to information, material and product flows from the original supplier to the delivery of the product to the end user. Juttner (2005) further notes that risk sources are any variable which cannot be predicted with certainty and from which disruptions in the supply chain can emerge. However, there is confusion in literature as disruption and disturbance are used inter-changeable to describe a consequence of a risk event. Sheffi and Rice (2005) note that a disruption is a random event which can be categorized into accidents (fires and explosions), intentional disruptions which consist of terrorist events (bombings) as well as non-terrorist events (labour strikes), and natural disasters which are natural hazards intersecting with the human environment (Blos *et al.* 2009). The literature suggests that natural disasters include geological events such as earthquakes, landslides, volcanic eruptions and avalanches; hydrological events such as tsunamis and maelstroms; climate events such as blizzards, droughts, heat waves, tornados, and typhoons; fires; disease epidemics and famine (Dynes 2003, McKean *et al.* 2007, and Perry 2007). With reference to supply chains, disruptive risks are *"unplanned and unanticipated events that disrupt the normal flow of goods and materials [...] and, as a consequence expose firms within the supply chain to operational and financial risks"* (Craighead *et al.* 2007, p. 132). Chopra and Sodhi (2004) point out, that disruptions are unpredictable and of relatively low probability, but high damage events. Kleindorfer and Saad (2005) introduce a three-way classification of supply chain disruption. They group disruptive risks into operational risks; risks arising from natural hazards; and risks as a result from terrorism as well as political instability. Operational contingencies include equipment malfunctions, system failures (e.g. power grid blackout, etc…), financial distress, and human-centred issues such as strikes and fraud. Risks from natural hazards encompass earthquakes, hurricanes, storms and floods. Finally, terrorist attacks and political sabotage are grouped in the last risk category. From a financial point of view, executives identify supply chain risks to have the greatest potential to disrupt their companies' revenue (de Waart 2006). The research by Hendricks and Singhal (2005) revealed that firms which experienced a disruption do not recover quickly, but continue to operate often for two years at a lower performance level in terms of sales, costs and stock price.

Distinguishing from a disruption, Svensson (2002b, p. 112) defines disturbance as *"a random quantitative and qualitative deviation from what is normal or expected".* Based on this definition, this thesis defines disturbances as everyday operational fluctuations that are managed through normal control mechanisms. Accordingly, negative consequences of disturbances affect a firm's goal in increased economic costs, quantitative deviations such as

increased cycle times and machine failures, and qualitative deviations such as non-functioning products for example (Svensson 2002b). Kleindorfer and Saad (2005) refer to disturbances as normal risks which are associated with the coordination of supply and demand between multiple actors along the supply chain, i.e. the interaction within a supply network. The research by Pfohl *et al.* (2010) shows, that disturbances are predominantly caused by weak relationship management with business partners as well as poor co-ordination of the involved supply chain organisations, and can be prevented by measures such as buffers, for example. Svensson (2002b) says that difficult inter-relationships between firms often cause disturbances such as technical adaptation problems; time issues; lack of knowledge about each other; weak social bonds; and legal conflicts. According to Pfohl *et al.* (2010), the difference between a disruptive event and a SC disturbance is the sphere of action and duration of effect, which is much more severe for a disruption than in the case of a disturbance. However, cumulated or co-incidental disturbances can also result in a disruption of a supply network, particularly if they are left unchecked or poorly managed.

As the nature of supply chain risk varies widely, the focus on risk sources is often different (Rao and Goldsby 2009). Table 4-1 summarises different risk categories by author(s) and highlights any identified risk that can be related to 'climate' or 'environmental' risk.

Authors	**Year of publication**	**Risk Categories**	**Elements related to climate**
Rao and Goldsby (based on work by Ritchie and Marshall)	2009 (1993)	• Environmental • Industry • Organization - (problem specific) - (decision maker related)	"Natural uncertainty: floods, earthquakes, fires" listed in the category *Environmental*
Manuj and Mentzer	2008	• Supply • Demand • Operational • Other/Security risks	No reference to climate
Cheng and Kam	2008	• Environmental • Infrastructure • Service delivery • Organisational and relationship	No reference to climate
Wagner and Bode	2008	• Demand side • Supply side • Regulatory, legal, and bureaucratic • Infrastructure • Catastrophic	"Natural hazard" included in the category *catastrophic*

Wu *et al.*	2006	• Internal controllable • Internal partially controllable • Internal uncontrollable • External controllable • External partially controllable • External uncontrollable	"Natural disasters" included in the category *external uncontrollable*
Peck	2005	• Value stream/product/processes • Asset & infrastructure dependencies • Organisations & inter-organisational networks • The environment	"Natural phenomenon – geological, meteorological and pathological" as part of the category *Environment*
Kleindorfer and Saad	2005	• Operational contingencies • Natural hazards, Earthquakes, Hurricanes, and Storms • Terrorism and Political Instability	Second category mentioned natural phenomena
Juttner	2005	• Environmental • Supply & demand • Process & control amplifier/absorber	"Natural risks" mentioned in *Environmental* category
Spekman and Davis	2004	• Goods • Information • Money	Mentioned "natural disasters" and acts of nature" as part of the category "Goods"
Hallikas *et al.*	2004	• Demand problems • Problems in fulfilling customer deliveries • Problems of cost management and pricing • Weakness in resources, development, and flexibility	No reference to climate
Giunipero and Eltantawy	2004	• Material availability • Long distances • Insufficient capacity • Demand fluctuations • Technological changes • Financial instability • Labour instability • Management turnover	No reference to climate
Finch (based on work by Bandyopadhyay *et al.*)	2004 (1999)	• Application level • Organisational level • Inter-organisational level	"Natural disasters" included in the category *Application level*
Chopra and Sodhi	2004	• Disruptions • Delays • Systems • Forecast • Intellectual Property	"Natural disasters" included in the category *disruptions*

		• Procurement • Receivables • Inventory • Capacity	
Christopher and Lee	2004	• Sales • Customer Service • Operations • Marketing • Raw material supplier	No reference to climate
Christopher and Peck	2004a	• Internal to the firm • External to firm but internal to the supply chain network • External to the network	"Extreme weather or natural disaster" are listed in *External to the network* category
Cavinato	2004	• Physical • Financial • Informational • Relational • Innovational	No reference to climate
Svensson	2004	• Time dependence • Functional dependence • Relational dependence	No reference to climate
Juttner *et al.*	2003	• Environmental • Network • Organisational	"Acts of good, e.g. extreme weather" included in the category *Environmental*
Zsidisin *et al.*	2000	• Business • Supplier capacity constraints • Quality • Production technology/design changes • Disasters	"Floods, hurricanes, blizzards, fires" are listed in the category *Disasters*

Table 4-1: Supply chain risk categories by author

The review of the supply chain risk literature revealed different approaches to categorise various types of risk. Some authors investigate very precise SC risks such as Kleindorfer and Saad (2005), Svensson (2004), and Zsidisin *et al. (2000)*. Others take a holistic perspective and provide broader and more general categories. Christopher and Peck (2004) distinguish between risks which are 1) internal to the firm; 2) internal to the supply network, but external to the firm; and 3) risks which are external to the network. Peck (2005) suggests that the different risks operate at four levels within a supply network. Her multi-level framework distinguishes between the value stream (level 1); assets and infrastructure dependencies (level 2); organisational and inter-organisational networks (level 3); and the environment (level 4). The latter comprises political, economic, social, technological, environmental and legislative

(PESTEL) risks. It can be argued that both presented risk frameworks are superordinate concepts as all other categories can be classified in one or the other category by Christopher and Peck (2004) and Peck (2005). However, across all approaches to categorise SC risks, external risks to an organisation or to the supply chain are referred to as 'environmental risks' or 'natural risks'. In this context, environmental risks are often understood as natural disasters such as fires, extreme weather, earthquakes, and act of god (Zsidisin *et al.* 2000; Juttner *et al.* 2003; Christopher and Peck 2004a; Spekman and Davis 2004; Juttner 2005; and Peck 2005). Clarifying this environmental category, risks are not automatically limited to natural or ecological operational activities. It often involves all processes which are defined as external to the firm. For example, Rao and Goldsby (2009) include political instability, shifts in government policy, macroeconomic uncertainties, social uncertainties, and natural uncertainties in their analysis of environmental risk sources. Accordingly, each paper requires an individual assessment of how the term environment is defined.

In conclusion, SCR research disregards climate change as an external risk to supply chains. It might only address some fragments of climate change such as extreme weather, for example, or refer to it as 'act of god'. None of the broadly reviewed literature specifically includes climate change as a source of risk to supply chains nor does it recognize the likely increase in frequency and intensity of disruptive climate events as a result of climate change.

4.3.1 Supply chain vulnerability

The Oxford Concise Dictionary defines vulnerability as *"exposure to the possibility of being attacked or harmed, either physically or emotionally".* Taking a supply chain perspective, Juttner (2005, p. 124) argues that vulnerability is *"an exposure to serious disturbance [or disruption] arising from supply chain risks and affecting the supply chain's ability to effectively serve the end customer market".* Similarly, Chapman *et al.* (2002, p. 60) note, that supply chain vulnerability is *"an exposure to serious disturbance [or disruption], arising from risks within the supply chain as well as risks external to the supply chain".* They further state that even the most secure and stable supply chain is vulnerable to unforeseen changes, both in the nature of a relationship and in the environment a supply chain is embedded in. Sheffi and Rice (2005) explain relationships between a (negative) consequence and the probability disruption in their vulnerability framework as shown in Figure 4-1.

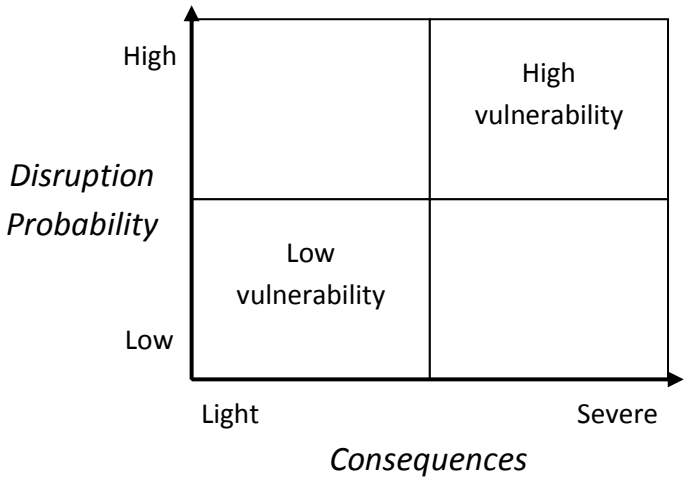


Figure 4-1: Vulnerability framework
Source: Sheffi and Rice (2005, p. 43)

The bottom left corner represents the lowest vulnerability level with rare and low consequence events which require little management action. In contrast, the top right quadrant identifies vulnerability events with high likelihood and severe consequences. From a SC perspective, all risks along the supply chain must be identified and dependent on the supply network, these risks might increase a SC's vulnerability. Clarifying the relationship between risk and vulnerability; climate risks make a SC vulnerable if they interact with the network structure. Accordingly, the more risks a supply network faces at different locations around the world, the higher it overall vulnerability will be. To reduce SC vulnerability, the detection of risks plays a key role in globalised markets. Interviewing 400 senior executives, Butner (2010) revealed that risk management, visibility, and globalisation rank among the top five supply chain challenges for the future. Her research shows that SC visibility is increasingly important to reduce SC vulnerability. In a globalised world, necessary and appropriate mitigation activities can be planned only if decision makers obtain up-to-date and accurate information on potential risks that may lead to SC disruptions and decrease a firm's competitiveness.

4.3.2 The problem of supply chain climate risk (SCCR)

The review of supply chain risk literature reveals that climate change and its expected effects have been disregarded as a source of external risk to supply chains. This may due to the fact that climate change has only recently begun to be understood in more detail and therefore has not been high on the agenda of business management researchers so far. Another reason might be that the latest research findings regarding the importance of climate change for supply chains face a time lag of up to 24 months until they are published in academic journals. Accordingly, publications could already be in the pipeline without being considered in the

literature review. The recently published report by the Royal Academy of Engineering (2011) assessed the impacts of climate change on UK infrastructure. It identified the need to respond in two forms: *"dealing with long term effects on the infrastructure such as rising sea levels, and developing resilience to acute and extreme weather events such as flash flooding"* (p.5). Although, the public sector has increasingly become aware of the need to mitigate to climate risk, no research has been published to the author's knowledge of how supply networks in the private sector can respond to climate risk.

Therefore, climate change and each of the five presented climate risk factors are added as external risks to the supply network as shown in Figure 4-2 and the following definition of supply chain climate risk (SCCR) is proposed:

> *"Supply chain climate risk (SCCR) is the probability and direct and indirect consequences to the supply chain emanating from changes in the political, economic, social, technological, environmental and legislative environment caused by climate change"*

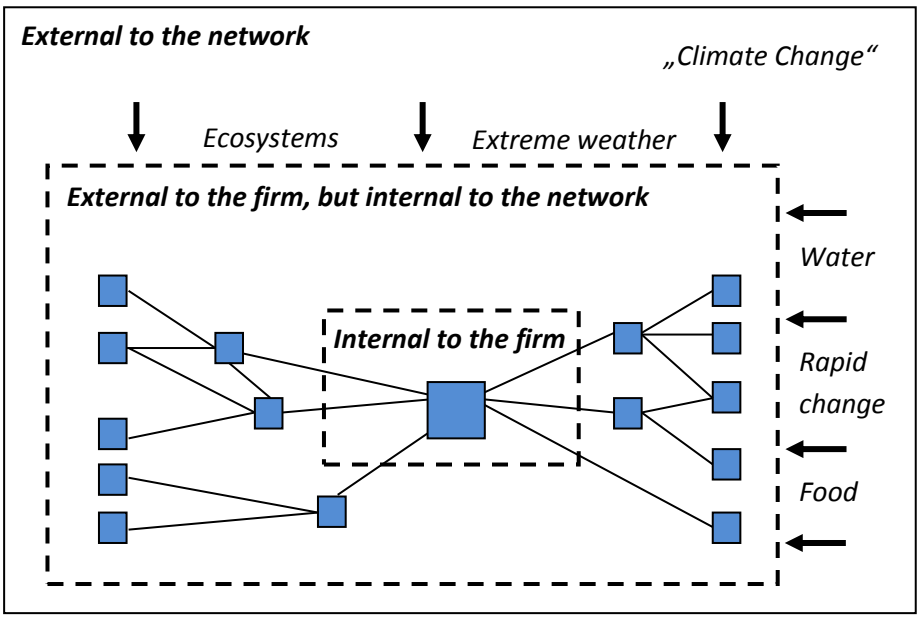


Figure 4-2: Climate change as external SC risk source

It is reasonable to argue that SCCR differentiates from other supply chain risks as no historical data is available that enables organisations to determine the probability and direct as well as indirect consequences. Although climate scientists have collected rich data to prove climate change (IPCC 2007c), information about previous impacts on supply chains as a result of

climate change are rare. Therefore, statistical calculations to evaluate the significance of SCCR are difficult to produce. In particular, SCCR differs dependent a) on the scale of global warming; and b) on the location as consequence and probability are not uniform worldwide. Initiatives such as undertaken by insurance companies and the IPCC have begun to address these problems by specifically determining the risk of increasing extreme weather events as a result of a changing climate (IPCC 2007c). Nevertheless, it can be concluded that SCCR remains highly uncertain.

4.4 Supply chain risk management (SCRM)

In any discipline, the objective of risk management is to protect the business from adverse events and their effects (Gaudenzi and Borghesi 2006). In supply chain risk management (SCRM), this objective refers to risks which make supply chains vulnerable and which prevent them from processing products and information to the customer. SCRM aims to reduce the probability of risk events and to increase supply chain resilience (Pujawan and Geraldin 2009). Juttner (2005, p. 124) defines SCRM as *"the identification and management of risks for the supply chain, through a co-ordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole"*. According to Norrman and Jansson (2004) SCRM focuses on the understanding and avoidance of the devastating effects which disasters or even minor business disruptions can cause and negatively impact on supply chain performance (Blackhurst *et al.* 2005). Hence, Hallikas *et al.* (2004) note that SCRM provides a framework to analyse the individual characteristics of risks in order to develop suitable mitigation strategies. Much knowledge has been gained about risk management from research in single companies, but cannot always be translated to a complex network perspective. Mentzer *et al.* (2001) broaden the problem to at least three parties: the focal firm, a supplier and a customer involved in the flows of products and information. In this case a broad scope of processes must be borne in mind and increases the complexity of a supply network. Differentiating from a single firm, Wu *et al.* (2006) note that a typical supply chain has many tiers and that a linear flow of goods is quite rare as each tier is often part of multiple supply networks as discussed in chapter Chapter 2:. Table 4-2 lists a number of developed SCRM frameworks. The different approaches range from a simple three stage construct (e.g. White 1995; Kleindorfer and Saad 2005, etc…) to a more detailed process such as provided by Harland *et al.* (2003). Despite some variations, it is reasonable to conclude that a basic SCRM construct has emerged among the different authors which usually includes the three elements *risk identification*, *risk assessment* and *risk mitigation.*

Authors	Year	SCRM constructs
Ritchie and Brindley	2007	- Risk sources & profile - Risk & performance drivers - Risk & performance consequences - Risk management responses - Risk & performance outcomes
Kleindorfer and Saad	2005	- Specifying resources of risk and vulnerabilities - Assessment - Mitigation
De Waart	2006	- Specific: Define Risk - Measurable: Quantify Risk and Impact - Actionable: Define Risk Mitigation Initiatives - Realistic: Understand Resource Constraints - Time-Phased: Lay out the Timeline
Gaudenzi and Borghesi	2006	- Risk assessment (analysis and evaluation) - Risk reporting and decision - Risk treatment - Risk monitoring
Finch (based on work by Bandyopadhyay *et al.*)	2004 (1999)	- Risk identification - Risk analysis - Risk reduction - Risk monitoring
Sinha *et al.*	2004	- Identifying - Assessing - Planning and implementing solution - Conduct failure modes and effects analysis - Continuously improve
Norrman and Jansson	2004	- Risk identification - Risk assessment - Risk treatment - Risk control
Hallikas *et al.*	2004	- Risk identification - Risk assessment - Decision and implementation of risk management actions - Risk monitoring
Hauser	2003	- Identify processes and risks - Identify vulnerabilities - Refine financial model - Define complexity/risk portfolio - Finalize model - Develop initiatives - Measure performances
Juttner *et al.*	2003	- Supply chain risk sources - Risk consequences - Risk drivers - Risk mitigation
Chapman *et al.*	2002	- Risk identification - Risk assessment - Supply chain continuity management and co-ordination processes - Processes to ensure learning from experience

Harland *et al.*	2003	- Map supply network - Identify risk and its current position - Assess risk - Manage risk - Form collaborative supply network risk strategy - Implement supply network risk strategy
White	1995	- Risk identification - Risk estimation - Risk evaluation

Table 4-2: Overview of SCRM constructs

4.4.1 SCR assessment

In order to assess the impacts of climate change for supply chains, possible changes in the PESTEL business environment need to be considered. Table 4-3 summarises already observed changes in the five climate risks factors for each PESTEL factor as a result of climate change. However, as scientists are uncertain about an exact projection of the future climate, risk assessment remains difficult for the following reasons:

- The likelihood and consequence of each climate factor differ dependent on the scale of global warming (Stern 2006). It is therefore reasonable to conclude that the higher the global average surface temperature, the higher the probability for an event to occur and the stronger the consequences for supply chains.
- In order to assess the impacts and probabilities of climate change a distinct form of language must preferably be used due to the high level of uncertainty. Accordingly, the scale ranges from low to high instead of percentages or any other more precise form of numbers.
- Each climate factor requires an assessment at the local scale as consequence and probability are not uniform for all worldwide locations in the supply network. Yet, the measures for each climate risk factor are usually provided as global means only.

In conclusion, the assessment of SCCR remains difficult as much uncertainty exists. The better the local information about climate change, the better and more accurate can organisations respond to the likely impacts.

	Water	Food	Ecosystems	Extreme weather	Risk of rapid climate change
	• *Sea level rise* • *Flooding* • *Reduction in fresh water*	• *Major declines in crop yields* • *Collapse of food supplies*	• *Irreversible (partial) damage of coral reefs and rainforests* • *Extinction of many species*	*Rising intensity of storms, floods and forest fires*	• *Tipping elements may lead to accelerated climate change* • *Linear trend of climate change is likely to turn exponential*
Political	Collaboration in political initiatives at the European and global level; exporting embargos in food supplies for own use in developing countries; increased subsidies for the agricultural sector				All impacts are likely to occur more frequently and at accelerated speed; i.e. the time to design agile and adaptive supply chains in response to changes in the PESTEL environment as a result of SCCR is significantly shortened.
Economical	- Destruction of production and logistics facilities - Reduction in fresh water supply (e.g. in the FMCG sector)	- Shortages in production input, as agricultural products are key ingredient to many products, particularly in the FMCG sector. - Increase in costs for natural ingredients.	- Closure of transportation routes in order to protect affected ecosystems - Decrease in productivity in the agricultural sector due to loss of soil nutrition	- Destruction of production and logistics facilities - Increased financial risk; rising insurance premiums - Transportation delays (Blackhurst *et al.* 2005).	
Social	Humanitarian logistics becomes more important to provide people with fresh water	Humanitarian logistics becomes more important to provide people with food		- Resettlement of people to more safer regions - Increased number of casualties	
Technological	Development of new flood barriers for coastal areas	- Development of new harvesting machines and fertilizers for the agricultural sector. - Genetically modified seeds that are more robust to CC		- Need for more robust production and logistics facilities, e.g. stronger roofs to cope with increasing snowfall - Redesign of transportation infrastructure, e.g. bridges, roads	
Environmental	Increasing areas suffering from drought; re-zoning of agricultural production	Re-zoning of agricultural production	No resistance of flora and fauna to a changed environment	Destruction of crops	
Legal	Stricter regulations such as: CO_2 emission limits; increase in taxes; increased bureaucracy; city environmental zones				

Table 4-3: Potential climate risks for supply chains

The assessment reveals that SCCR can have direct or indirect impacts on supply chains. The two climate risk factors water (flooding) and extreme weather events impact directly on supply chains and result in temporarily and partially SC break downs. Direct climate impacts lead to SC disruptions and prevent them from fulfilling their purpose to forward goods and information between the involved organisations and the customers. Usually, these events occur randomly, often frequently and last only for a limited period of time, i.e. disruptive events are often discrete. They can also be controlled only little by humans, although a reduction in GHG emissions is likely to result in a decrease of these disruptive events. In contrast to disruptive events, the remaining categories water (sea-level rise), food, ecosystems, and risk of rapid climate change impact on supply chains indirectly. According to climate projections (IPCC 2007c), these risk factors are expected to change continuously over time whereas the growth rates differ dependent of the applied climate scenario. These factors are not necessarily associated with sudden disruptive events and might be expected to develop incrementally as surface temperature rises. Hence, these risks will impact supply chains indirectly as rising awareness about the possible future impacts are expected to result in shifts in the political, economic, social, technological, legislative, and environmental landscape. Moreover, interdependencies exist between the five climate risk factors as extreme weather events (e.g. hurricanes, etc…) or flooding may not only destroy SC facilities, but also crop yields and so impact on the climate factor food. These interactions increase the complexity of SCCR.

4.4.2 SCR mitigation

In order to provide a solution to SCCR it is looked into the literature on supply chain resilience for suitable mitigation strategies. According to the Oxford Concise Dictionary, *resilience* (of an object or substance) is "the ability to recoil or spring back into shape after being stretched or being compressed" or (for a person or animal), the ability *"to withstand or recover quickly from difficult conditions".* Ponomarov and Holcomb (2009, p. 131) refer to supply chain resilience as *"the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function".* Resilience is related to the terms risk as well as vulnerability and admits that not all existing risks can be avoided, controlled or eliminated (Peck 2006). Rather, from a SCRM viewpoint Christopher and Peck (2004a, p. 2) define resilience as *"the ability of a system to return to its original or [...] desirable state after being disturbed".* On the one hand, the definition takes into account a certain degree of flexibility and is comfortable with supply chains to be viewed as interactive networks. On the other hand, the desired state to achieve after being disturbed implies not only a return to the previous shape, but allows for an adaptation to a newly determined and desired position or

structure. Sheffi and Rice (2005) also note that the reduction of supply chain vulnerability, e.g. reducing the likelihood of a disruption, leads to increased resilience and the *"ability to bounce back from a disruption"* (p. 41). Accordingly, resilience is strongly linked to a company's competitive position and the responsiveness of its supply chain. For this thesis, resilience not only refers to bouncing back from disruptions, but also refers to preparing the supply network to steady changes in the business environment. Accordingly, resilient supply chains enable corporations to secure or enhance their market position despite being significantly affected by disruptive events and continuous changes in the PESTEL environment.

Craighaid *et al.* (2007) note that supply chain resilience is strongly related to supply chain design characteristic (density, complexity, node criticality) and supply chain mitigation capabilities (recovery and warning). Christopher and Peck (2004b) introduce five principles of supply chain resilience in response to external disruptions including: supply base strategy; supply chain collaboration; creating a supply chain risk management culture; supply chain reengineering; and agility. The first three principles refer predominately to risks which are internal to the supply network. They deal with sourcing strategies, supplier relationship management, transparency of information amongst supply chain members, supply chain continuity management, and cross-disciplinary SCRM team building to achieve a formalised SCRM assessment. The two latter principles regard both internal and external risks to supply chains. Supply chain reengineering refers to the understanding of the network structure that connects the business to its upstream and downstream partners. Mapping the network, critical paths and weaknesses to internal as well as external risks can be identified and reengineered. Finally, agility is noted as *"one of the most powerful ways of achieving resilience in the supply chain through the creation of networks that are capable of a more rapid response to changed conditions"* (Christopher and Peck 2004b). Similarly to the presented five key principles of supply chain resilience, Lee (2004) introduces the triple-A supply chain to achieve sustainable competitive advantage. Such supply chains display the characteristics of agility, adaptability, and alignment to be successful in mitigating SC risks. Each component can be described as follows:

Agility

Christopher (2000, p. 37) defines agility as *"a business-wide capability that embraces organisational structures, information systems, logistics processes and, in particular, mindsets".* Agility is originally referred to as strategy when the marketplace demand is highly volatile (Mason-Jones *et al.* 2000), i.e. agility addresses the problem of supply and demand risks that are within the supply network. The concept of agility is strongly linked to total

product cycle analysis (Mason-Jones and Towill 2000), such as to be found in the textile and fashion industry, for example, with short product life cycles and strong fluctuations in demand (Christopher *et al.* 2004). Van Hoek *et al.* (2001) note, that agility is all about customer responsiveness and mastering market turbulences. Accordingly, an agile firm therefore designs its organisational structures, processes, and products in order to respond to changes in a useful time frame (Prater *et al.* 2001). Blackhurst *et al.* (2005) stress, that agility is a key issue in dealing with disruptions and as a supply chain is often that part of a firm's sphere which is most severely affected by changes, agility enables organisations to thrive in a continuously changing and unpredictable business environment. So, Christopher (2000) argues that agility is needed in less predictable environments, where demand is volatile and the requirement for variety is high. Lee (2004) adds to this traditional field of application, that smart companies could use the concept of agile supply chains to also cope with emergencies as a result from risks that are external to the supply chain. Such risks have been broadly discussed in literature (Kleindorfer and Saad 2005, Sheffi and Rice 2005, Christopher and Peck 2004, Chopra and Sodhi 2004, Martha and Subbakrishna 2002) and may include natural events, terrorism, wars, epidemics, and computer viruses which have intensified in recent years. In order to mitigate such external risks, supply networks should create capabilities to respond quickly through the precautionary development of contingency plans and crisis management (Lee 2004) and multiple sourcing and production systems that accommodate multiple products and real time changes (Rice and Caniato 2003). Being agile, capacities in one area can be deployed to overcome the loss of capacities in another area that suffer from a natural disruptive event. Rice and Caniato (2003) group the different activities to achieve a flexible supply chain by five key business areas (failure mode) as shown in Table 4-4. These activities allow for a quick recovery from direct and temporarily climate impacts by accessing well prepared strategies and alternatives. Therefore, it can be concluded that the concept of agility is eligible to cope with direct climate impacts (e.g. extreme weather) on supply chains that have disruptive character and require operational flexibility to maintain continuous customer service.

Resilience to a natural disruption in:	Strategy/Activity
Supply	Use multiple suppliers to guaranty continuous supplies
	Modify inventory levels (raw materials)
Transportation	Use multiple carriers
	Identify alternative routing and mode of transport
Production Facilities	Use multiple sites
	Modify inventory levels (finished goods)
	Identify backup production facilities
Communications	Back up data
	Set up parallel systems
Human Resource	Cross trained workers in production
	Multi-skilled employees

Table 4-4: Activities for supply chain resilience to disruptions by failure mode
Source: adapted from Rice and Caniato (2003)

Adaptability

Resilience is often thought to be related to adaptability (Woods 2006) which has been defined as 'the ability to become adjusted to new conditions' or 'to be made suitable for a new use or purpose' (Oxford Concise Dictionary). Woods (2006) states that adaptability is considered to be *"the ability to absorb or adapt to disturbance, disruption and change"* (p. 21). Lee (2004) refers to adaptability as the ability to *"adjust the supply chain's design to meet structural shifts in the market"* (p. 105). An adaptive supply chain will evolve over time and addresses the reshape of markets due to economic progress, political shifts, and technological advancement in order to gain sustainable advantage. With reference to Christopher and Holweg (2011), flexibility in the structure enables a supply chain to adapt to structural shifts in the market. The best supply chains identify structural shifts, ideally before they actual occur by capturing the latest data and tracking key patterns (Lee 2004). This implies a constant scanning of the environment and the ability to spot trends as well as the capability to change supply networks. In the context of climate change, there is much uncertainty regarding the impacts of SCCR. Therefore a constant examination of the business landscape is necessary in order to prepare the SC for a changing environment. It can reasonably be argued that adaptation is required to prepare supply chains to PESTEL changes (e.g. scarcity of fresh water and crops; rezoning of agricultural production, etc…) that have a steady and long-term impact characteristic. Indeed, if the rate of climate change and its related environmental effects is non-linear, there might be no luxury of adapting supply chains gradually to a warming planet. If climate change proves to be catastrophic rather than incremental, supply chains will have to adapt pre-emptively rather than responsively.

Alignment

Supply chain alignment refers to the creation of incentives for a better performance across the supply network. Lee's (2004) third characteristic for a competitive supply chain includes intensive exchange of information and knowledge as well as transparency of tasks and sharing of risks and costs. Supply chain alignment predominately refers to the interaction between involved parties in the upstream and downstream processes. Van Hoek *et al.* (2001, p. 126) argue that *"companies have to align with suppliers, suppliers' suppliers, customers, customers' customers to streamline operations".* As each corporation focuses primary on its own interests above those of its partners, successful supply chains reduce this misalignment through enhanced communication and strategy sharing. Accordingly, alignment refers to Peck's third level in her framework and takes into account the complex nature of supply chains as discussed in the second chapter. Whereas the design of appropriate adaptation strategies is a response to the impacts arising from climate risk as part of Peck's fourth level, the actual implementation process involves the organisations at the third level. Accordingly, adaptation efforts affect a complex supply chain structure and the different inter-relationships between the entities must be addressed during the adaptation process. Although external risks might not impact directly on inter-organisational relationships, the complex structure of a supply network needs to be integrated in adaptation procedures. In conclusion, aligned businesses can improve the capabilities of a supply network to absorb knowledge of the impacts of climate change. Through a collaborative approach, a mutually agreed supply network structure comprising the concepts of agility and adaptation can be developed to become resilient to a changing business environment.

4.5 Robustness

Apart from creating a resilient supply chain to climate change through Lee's triple-A strategies, the goal is also to design a robust supply chain (Martha and Subbakrishna 2002). The term robustness means *"strong or sturdy in physics or construction"* (Christopher and Peck 2004a, p. 2) and is related to the physical strength of properties and fixed assets of logistics corporations. Moreover, robustness to disruptive risks is determined by the weakest link in the supply chain leading to the need of early warning and crisis management (Kleindorfer and Saad 2005). Tang (2006) argues that a robust supply chain strategy would make a supply chain more resilient and enables a firm to continue its operations during a major disruption. Accordingly, a robust supply chain is able to withdraw reasonable levels of disruptions and provides consistent outputs with very little variation only. In this context, useful approaches which are often introduced across corporations are Total Quality Management (TQM) and Six Sigma

(Tang 2006; Christopher and Rutherford 2004). In this thesis robustness refers to the physical ability of fixed assets to cope with impacts caused by climate change. For example, logistics centres must be designed sufficiently robust to extreme weather such as heavy precipitation or rising intensity of storms. This includes also the continuous functionality of IT-systems as well as communication standards. Yet, the research focus of this thesis is not primarily on SC robustness, but on SC resilience and adaptation.

4.6 Summary

Although each of the three literature chapters, supply chain management (SCM), climate science, and supply chain risk management (SCRM) represents its own right of research, the literature review reveals the need to overlap them. Incorporating the identified climate risk factors which impact supply networks either directly or indirectly through PESTEL, Figure 4-3 presents an overview of the literature findings and the developed arguments toward this field of research. The overview combines findings from the reviewed climate science and supply chain risk literatures and put them in the context of supply chain management. Identifying the problem of supply chain climate risk (SCCR), SCRM is presented as solution and proposes supply chain resilience, comprising agile, adaptive and alignment strategies, as effective mitigation.

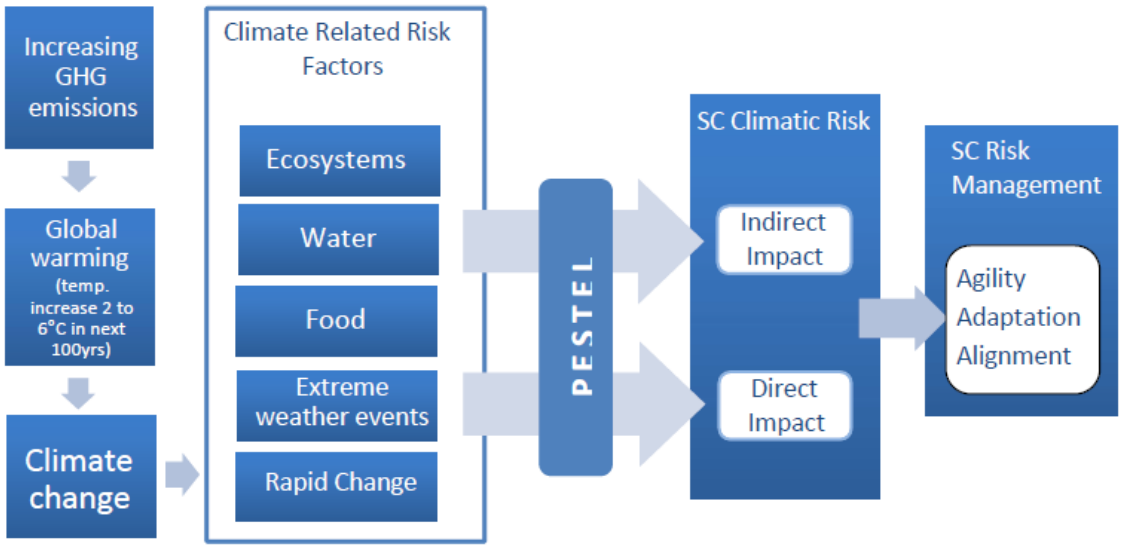


Figure 4-3: Summarised representation of literature findings

Despite the fact, that there is much uncertainty in the forecast scale of global warming over the next century, climate scientists basically agree that average surface temperatures will rise and lead to diverse consequences for the environment. Even with the certainty of global warming, supply chain risk literature has not yet explored the potential risks to supply chains

as a result of climate change. Yet, Halldorsson and Kovacs (2010) mention the impacts of climate change on supply chains as part of their sustainable agenda for the future. But they refer to them from a natural hazard perspective and mainly discuss disruptive consequences and humanitarian logistics as increasingly important fields of interests.

In response to SCCR, supply chain resilience and specifically the concepts of agility, adaptation and alignment are identified to enable resilience to climate risk. In particular, the element of adaptation is revealed to be the most appropriate concept to respond effectively to supply chain climate risks. Whereas Lee (2004), and Christopher and Peck (2004b) argue that a lot of literature on supply chain agility is available that offer solutions to may cope with direct climate impacts, literature on supply chain adaptation in response to indirect climate consequences is rare. For example, the agricultural business cannot simply source from different areas and re-zone their production facilities in order to become agile. Accordingly, not all elements of Lee's (2004) triple-A supply chain are well-researched in detail to enable SC resilience to climate risk.

Accordingly, the review of different research areas revealed the gap in literature that climate change has not been identified as potential risk source to supply networks and that adequate mitigation activities in response to the projected impacts are discussed only little by academics and practitioners. Concluding from the reviewed literature in SCRM, this thesis proposes the 'adaptation' of supply networks as solution to climate risk. However, the recommendation to make a supply network adaptable remains conceptual in nature. Blackhurst *et al.* (2005) comment that the literature on resilience is interesting and informative, and gives a good understanding of the 'big picture', but it falls short of drilling down to the key variables and the methodologies to manage key issues, thus increasing the practical utility (Datta 2007). This problem might also contribute to managers' perceptions that the risk of overinvesting in needless resilience and adaptation is currently much stronger than the risk of business break downs (The Royal Academy of Engineering 2011). Addressing this criticism, this research aims to also provide managerial implications that allow decision makers to put into practice the resilient concept of adaptation. Therefore, the overall research aim of this thesis is as follows:

Overall research aim:

"The aim is to determine how supply networks can adapt to climate change and its related risk factors"

As the reviewed literature in supply chain risk management has not revealed a process that helps to design and implement the concept of adaptation to climate change, the next chapter looks into the literature in ‘knowledge management’ and ‘learning’ to identify concepts that enable the adaptation process of supply networks to the identified climate risks.

Chapter 5: Knowledge and learning

5.1 Introduction

Knowledge management and the principles of learning enable organisations to better understand the dynamic changes in the environment, to analyse the resulting risks for the supply network and to facilitate the necessary adaptation activities. Premium capabilities in knowledge management and learning can lead to the successful adaptation of the business and eventually to a sustained competitive advantage. Referring to SC mitigation and sustainability that aims to 'greening' SCs, Smith (2011) notes that how much better off we would be today, if we had acted more sustainable in the past. Espinosa and Porter (2011, p. 55) support this perception and argue that *"the results are still poor compared with the need for change at individual, industrial and societal levels"*. In the context of climate change, managers should ask themselves how much more competitive they can become in the future, if they start immediately adapting their supply chains to the projected changes in the external business environment caused by climate change. Theories, such as *Knowledge Management* (KM) and *Organisational Learning* (OL), offer mechanisms for supply networks to generate the required knowledge and to develop new processes that could enable adaptation to climate change. Arguing that both disciplines are closely related to each other, different concepts of knowledge creation are discussed and how learning processes at the individual, organisational, and inter-organisational level can enable adaptation.

5.2 Knowledge management

Bhatt (2000a, p. 16) defines knowledge as *"an organized combination of ideas, rules, procedures, and information"* and argues that meaning, which is made by the mind, translates information into knowledge. Various authors (Mishra and Bhaskar 2010; Bierly *et al.* 2000; and Prahalad and Hamel 1990) point out that unlike other success factors in business such as equipment and labour, for example, knowledge is theoretically infinite and therefore *"the last and only sustainable untapped source of competitive advantage in business"* (McEllroy 2000, p. 195). Stonehouse and Pemberton (1999) and Bhatt (2000a) note, that core competences, such as knowledge, must be non-substitutable, durable and adaptable to ensure constant and excellent performance. As such, Nonaka (2004) argues that knowledge is created by individuals and that organisations cannot create knowledge without individuals. He concludes that *"organisational knowledge creation, therefore, should be understood in terms of a process that 'organizationally' amplifies the knowledge created by individuals, and crystallizes it as part of the knowledge network of an organisation"* (p. 169). Accordingly, the definition of knowledge includes three key parts (Nonaka and von Krogh 2009). First, knowledge is a justified belief

system in which individuals justify their truthfulness of beliefs in the world's context they live in (Nonaka 1991). Taking the same view, Bhatt (2000b) demonstrates that belief systems change constantly in a complex and dynamic environment and are reshaped through social interactions and information exchange. These interactions and exchanges help companies to build up-to-date knowledge and allow them to adjust their belief systems. Second, knowledge is the actuality and potentiality of skilful action that allows individuals to *"define, prepare, sharpe, and learn to solve a task or a problem"* (von Krogh *et al.* 2000). Third, knowledge can be explicit or tacit as initially introduced by Polanyi's (1967) discussion about different knowledge dimensions. Explicit knowledge can easily be articulated and codified, and is captured and distributed in the form of different formats such as documents, drawings or best practices. In contrast, tacit knowledge is very personal and cannot easily be extracted from people as it is difficult to articulate through rules and iteration. Derived from these two concepts, Nonaka (1991; 2004) concludes on four modes of knowledge creation as illustrated in Figure 5-1.

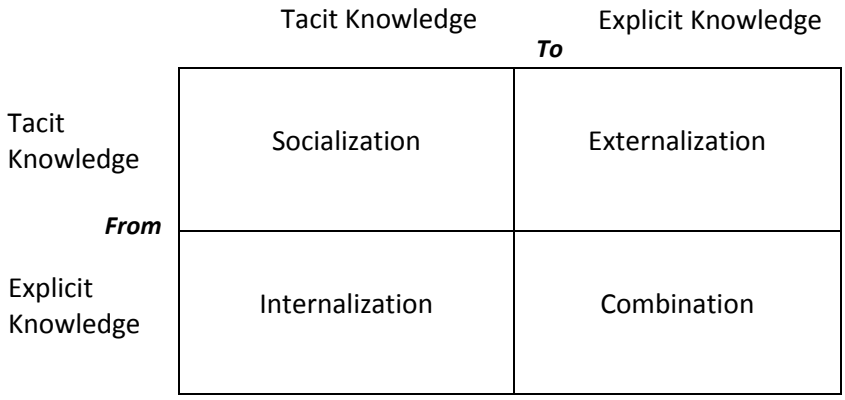


Figure 5-1: Modes of knowledge creation
Source: Nonaka (2004)

Each quadrant of the matrix is explained as follows (Nonaka 1991):

- **Socialization:** This quadrant represents the mode of knowledge conversion that enables the conversion of tacit knowledge through interaction between individuals. For that reason transfer of tacit knowledge occurs through moving people within or between organisations and personal interactions. It does not necessarily include language, but can also occur through observation, experience, imitation and practice.
- **Combination:** As part of this mode of knowledge conversion, differently held knowledge by individuals is combined through exchange mechanisms such as formal

or informal meetings. Nonaka (2004, p. 172) argues that *"the reconfiguration of existing information through sorting, adding, recategorizing, and recontextualizing of explicit knowledge can lead to new knowledge".*

- **Externalization:** The conversion of tacit knowledge into explicit knowledge is called externalization and involves the articulation of how an individual views the world. This mode of knowledge creation is critical to organisational learning as it requires a strong commitment of the individual to share its knowledge with others.
- **Internalization:** This mode refers to the conversion of explicit knowledge into tacit knowledge, i.e. the mutually developed explicit knowledge base is used to enhance and modify the individually held tacit knowledge.

Nonaka (2004) argues that these concepts of knowledge conversion contribute to the amplification and development of new knowledge and increase the capacity to create the organisation's competitive edge. He takes the position that knowledge alternates between tacit knowledge and explicit knowledge through socialization, externalization, combination, and internalization, and concludes on a spiral of organisational knowledge creation as shown in Figure 5-2.

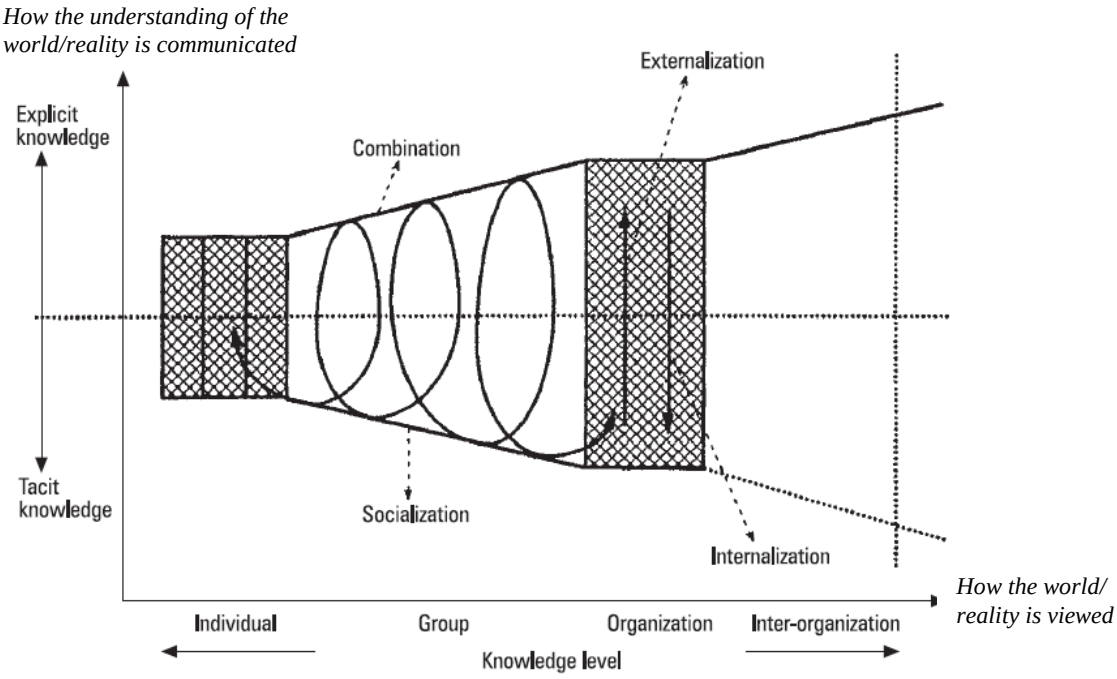


Figure 5-2: Spiral of organisational knowledge creation
Source: adapted from Nonaka (2004)

Figure 5-2 illustrates the development from individually held tacit knowledge towards organisationally held explicit knowledge. As part of the socialization mode, individuals experience and observe tacit knowledge from other organisational members (group level) and so shape their personal views of the world. In the externalization phase, the individually held perceptions are made public to the organisation and contribute to the organisational knowledge base. In order to make strategic decisions and set behavioural rules, all available knowledge is combined at the organisational level in order to make it accessible to each member of the firm and for the benefit of the entire organisation. Finally, each employee uses the organisational knowledge base to shape the own view of the world and to increase the individual knowledge base. In conclusion, organisational knowledge creation can be viewed as an upward spiral process that begins at the individual level and moves up to the organisational or inter-organisational level.

In order to foster organisational knowledge creation, Mishra and Bhaskar (2010) argue that knowledge management (KM) provides the necessary techniques and practices to facilitate the flow of knowledge into and throughout the organisation. McElroy (2000) distinguishes between first and second generation knowledge management. First generation knowledge management is all about individual performance and supplying information to support a task. It focuses on knowledge storage within an organisation and how existing knowledge can be mapped into operational processes. Second generation knowledge management offers implementation strategies for organisational knowledge creation and learning as it takes into account knowledge life cycles in human organisations. It focuses on how knowledge is created and how it is shared throughout the organisation. Its key objective is to satisfy organisational demand for new knowledge by creating the best conditions for knowledge production. As the creation of knowledge depends on how individuals and organisations learn, the next sections discuss the various theories and concepts of individual and organisational learning.

5.3 Learning and adaptation

The Oxford Concise Dictionary defines learning as *"the acquisition of knowledge or skills, through study, experience, or being taught".* Bhatt (2000b) argues that learning is necessary for knowledge generation whereas learning encompasses two different parts: the acquisition of *know-how*, i.e. what people learn; and the acquisition of *know-why*, i.e. how people understand and apply that learning (Kim 1993; 2004). However, even learning does not guarantee that the learned knowledge will be used to trigger adaptation activities to a changing environment. Investigating different learning structures and processes in more detail,

Garavan (1997, p. 27) argues that *"literature tends to view learning as a hierarchically ordered sequence of levels of learning"* which begins at the individual level and aggregates to organisational learning. Further at the network level, inter-organisational learning might contribute to the adaptation of the entire supply network to changes in the environment. Fiol and Lyles (1985) revealed that scientists refer to organisational processes for adjusting to the environment as change, learning, and adaptation. However, they argue that clarification on the different terminology is required as *"changes in behaviour may occur without any cognitive association development; similarly, knowledge may be gained without any accompanying change in behaviour"* (p. 806). In practice, organisations could frequently prepare changing strategies and restructure with very little learning taking place. However, organisations might better learn, formulate and solve problems with few well-defined rules that enable a constant adaptation of the organisation to a changing environment. Referring to learning and adaptation, both terms are closely linked together, but have a different meaning. Fiol and Lyles (1985) define both terms as follows (p. 811):

Learning: "The development of insights, knowledge, and association between past actions, the effectiveness of those actions, and future actions".

Adaptation: "The ability to make incremental adjustments as a result of environmental changes, goal structure changes, or other changes".

Integrating Fiol and Lyles' (1985) distinction between learning and adaptation, this dissertation takes the position that adaptation is part of the learning process. As such, the learning process encompasses the two recurring phases 'understand' and 'adapt' that alternate and represent a learning cycle, i.e. 'adaptation' follows 'understanding' follows 'adaptation' and so on. This emphasizes that learning at any level whether in the heads of individuals, in organisations and networks must initially begin to understand changes in their environment and then adapt to the identified changes. In particular, each adaptation activity triggers a new learning process as the newly created conditions, their effect on the environment, and updated information about changes in the environment must be understood first to respond through new adaptation activities. As the environment often changes non-linearly, the continuous learning process of an individual, an organisation or a network can also be dynamic and non-linear over time.

5.4 The learning organisation

Örtenblad (2001) refers to the *learning organisation* as a particular form of organisation that needs activity to learn. Senge (1990, p.3) defines learning organisations (LO) as *"organizations*

where people continually expand the capacity to produce the results they truly desire, where new and expansive patterns of thinking are nurture, where collective aspirations are set free, and where people are continually learning how to learn together". Simon (1991) points out that individuals are the learning entities as all learning takes place inside individual human heads. Accordingly, *"an organisation learns in only two ways: a) by learning of its members,* and *b) by ingesting new members who have knowledge the organisation did not previously have"* (Simon 1991, p. 125). He argues that organisations should be viewed as systems of interrelated roles and that individual learning is very much influenced by the organisational structures which can either facilitate or hinder particular learning of the enclosed individuals.

Bui and Baruch (2010, p. 208) stress that *"the concept of LO focuses on learning as a tool, a lever, and a philosophy for sustainable change and renovation in organizations in a fast-changing world".* Dixon (1994, xi) states that *"learning is a premium because we are not so much master of change",* i.e. a process is needed to deal with the inexorability of change, the unpredictability of the future, and the importance of imagination (Starkey *et al.* 2004). Montuori (2000) argues that the ability to learn is vital to survive in a changing environment and that newly developed insights must be transferred to all business departments, functions, and employees at all levels. Therefore, a LO provides the framework and culture for individual and organisational learning. It can be concluded that the key objective of a learning organisation is the ability to use existing knowledge efficiently and to create new knowledge of what is known or unclear and what is similar or different from the past and what will be relevant for the future. Bhatt (2000b) argues that a learning organisation is required to use different communication channels to link all members and to interact with the environment in order to refine its knowledge base. However, Holste and Fields (2010) refer to difficulties in sharing knowledge within organisations. They highlight the importance of tacit knowledge for an organisation and investigated the willingness of organisational members to share it. They concluded that face-to-face interactions are a preferred method to transfer tacit knowledge despite the fact that the share of tacit knowledge may result in disadvantages such as loss of competitive advantage for the sender. They further conclude on the positive relationship between trust among organisational members and their willingness to share and use tacit knowledge. It is well established in literature that social interaction is key to the effective transfer of tacit knowledge. In this context, a learning organisation needs to create a climate of trust to leverage the distribution of valuable tacit knowledge throughout the organisation in order to make the best of the organisation's knowledge. Pena (2002) notes that mutual trust and collaboration is gained only over time and requires the commitment of all involved entities

to the agreed structures and processes. In this context, Stonehouse and Pemberton (1999) argue that *"the pace of change accelerates the survival and performance of an organisation"* (p. 131), i.e. the speed of knowledge creation determines the competitiveness of an organisation. Accordingly, not only appropriate structures and processes determine the success of a learning organisation, but also its capability to learn quickly, i.e. the faster organisations learn in comparison to their market rivals, the more competitive they can become.

With reference to organisational longevity which is the durability and continuance of an organisation in an uncertain and turbulent environment, Montuori (2000) proposes three efforts to achieve a learning organisation. First, the interaction between an organisation and its environment must be understood to consistently identify and analyse significant changes. Second, an organisation's culture relies strongly on employees' involvement and empowerment and requires adaptation to ongoing changes in order to ensure organisational learning. This can be achieved if employees are willing to share tacit knowledge. And third, complex leaders must be appointed to foster knowledge and involvement from the two other efforts and create strategic changes.

Senge (1990) suggests a structure that involves five equally important and interconnected disciplines to achieve a learning organisation. At the individual level, *Personal mastery* stands for the personal commitment of continuously clarifying personal visions and seeing reality objectively. At the collective or group level, *Mental model* refers to assumptions or pictures of images which influence the understanding of the world and how individuals and groups take action. The discipline *Team learning* implies the alignment of a team's capacity in order to create the desired results of all its members. At the organisational level, *Shared vision* fosters a vision to which people at all levels in an organisation are committed to and which enables guidance for employees to a certain and common business direction. The fifth discipline *Systems thinking* integrates the four other disciplines whereas each can be viewed as an antecedent of the fifth one. System thinking oversees the underlying structures of complex situations and allows for analyzing the entire range of all the interconnecting elements.

Montuori (2000) argues that the system approach maps organisational complexity caused by a set of individual elements interacting over time. Bui and Baruch (2010) add to Senge's (1990) framework a set of antecedents and outcomes which attempt to make Senge's theory more applicable. They argue that Senge's five disciplines are influenced by a number of antecedents

such as motivation, organisational culture, and leadership. Besides these input factors, Bui and Baruch (2010) anticipate specific outcomes of a learning organisation such as *Strategic planning*, *Team performance*, and *Knowledge sharing* that enable the measurement of the effectiveness of a learning process within a complex system. Örtenblad (2004) takes this further and identifies flexibility in process and decision making as the ultimate outcome for a learning organisation which can be achieved *"with a decentralized, flat, team-based, informal structure, where everyone is empowered to act and make independent decisions – in the organization's best"* (p. 139).

Table 5-1 summarises Bui and Baruch's (2010) conceptual elements to describe the learning organisation. On the input side, eleven antecedents shape Senge's five disciplines. On the output side, eight outcome factors can measure the performance of the learning organisation. Bui and Baruch (2010) also introduce five moderators: *HR policies*, *Sector*, *Learning environment*, *Communication systems* and *Size* that may influence the structure and capabilities of the learning organisation.

Antecedents	**Senge's five disciplines**	**Moderators**	**Outcomes**
Competence Organisational culture Leadership	System thinking	HR policies	Strategic planning Organisational performance
Personal vision Personal values Motivation Individual learning Developing & training	Personal Mastery	Sector HR policies	Individual performance Self-efficacy Work-life balance
Organisational culture Organisation commitment Leadership	Mental models	Sector HR policies	Individual performance
		Learning environment Communication systems	Organisational performance Knowledge sharing
Developing & training Leadership Goal setting Team commitment	Team Learning	Learning environment Communication systems	Team performance Knowledge sharing
Personal vision Personal values Leadership Organisational culture	Shared vision	Size Communication systems	Individual performance Organisational performance

Table 5-1: Elements of the learning organisation
Source: adapted from Bui and Baruch (2010)

Each element might be investigated regarding its design to sufficiently learn about climate change. For example, mental models are influenced by the three antecedents *organisational commitment, leadership, and organisational culture* and are believed to lead to the outcomes knowledge sharing as well as individual and organisational performance. In the context of climate change, organisational commitment as heart of a LO facilitates peoples' learning about a changing environment and strengthens their willingness to acquire new knowledge of the environment in order to become adaptive. Leadership as second antecedent is essential to a successful LO as leaders identify organisational mental models and take responsibility for creating a learning environment at all hierarchy levels. Senge (1990) argues that leaders challenge their colleagues by posing the question for what values they really want to stand for. In other words, leaders who view climate change as external risk source to their business can encourage their staff to learn about a changing environment and develop adaptation plans to retain competitive. The third antecedent *organisational culture* refers to the idea that people should share and aim for the same values, beliefs and norms. In a globalised company, different cultures around the world influence the company's position to certain events and therefore require harmonization to adapt in a coordinated way to climate change. Agyris (1999) and Senge (2004) conclude that a higher level of knowledge creation and sharing is one of the outcomes when mental models were developed. Moreover, better knowledge creation and sharing can lead to improved individual and organisational performance, i.e. the more people share their created understanding about climate change, the better they can adapt the organisation to a changing environment. Bridging between developed mental models and the outcomes of a LO, moderators such as HR policies, sector, learning environment and communication systems shape the organisational structures. The industrial sector and the importance of HR policies within the organisation are supposed to influence the individual performance. Appropriate communication systems and a learning environment support the development of mental models and increase knowledge sharing and organisational performance. Accordingly, a LO needs to design structures that allow for fast sharing of knowledge of a changing environment and that create a learning environment to enable adaptation to climate change.

5.4.1 Levels of learning

Learning can follow two different levels as summarised in Table 5-2. Argyris and Schön (1978; 1996) introduced the often referenced concepts of single-loop and double-loop learning. Other authors such as Miles and Randolph (1980) speak about re-active and proactive learning and Fiol and Lyles (1985) distinguish between lower- and higher level learning. Senge (1990) refers to a similar construct of adaptive and generative learning.

Author(s)	Learning concepts	
	Level 1	**Level 2**
Argyris and Schön (1978)	Single-loop learning	Double-loop learning
Miles and Randolph (1980)	Re-active learning	Pro-active learning
Fiol and Lyles (1985)	Lower level learning	Higher level learning
Senge (1990)	Adaptive learning	Generative Learning

Table 5-2: Levels of learning

The concept of 'lower level learning' aims for a particular behavioural learning at short duration and replying to changes from the past. It means continuously improving current ways of doing things as a re-action to the understanding of previous actions without altering the nature of the activities. Lower level learning focuses on solving problems in the present without examining the appropriateness of current learning behaviours. Organisations that follow this approach focus on incremental improvements, often based upon the past track record of success and don't question the fundamental assumptions underlying the existing ways of doing work. Clear parallels can be seen between lower level learning and knowledge management and therefore organisations need to put in place first generation knowledge management structures.

'Higher level learning' aims at *"adjusting overall rules and norms rather than specific activities or behaviours and has long term impact on the organisation as a whole"* (Fiol and Lyles 1985, p. 808). It is also generic and proactive learning that includes the capacity to question the courses of action (Argyris and Schön 1978). According to Senge (1990; 2004) higher or generative learning requires new ways of looking at the world and enhances the capacity to create. Engaging in higher level learning involves linking existing knowledge of a subject with emerging ideas that result in a more individualized understanding about its systemic significance. Higher level learning can occur when existing knowledge gained from previous actions is not sufficient and *"when decision makers recognize that an epistemic gap exists that must be closed with new knowledge"* (p. 180). Sotirakou and Zeppou (2004) argue that a learning organisation has the capability to transfer knowledge into problem solving, creating new knowledge, and successfully adapting to environmental changes thus increasing organisational knowledge by challenging the status quo. Argyris interviewed by Fulmer and Keys (2004) stresses that double-loop learning is needed to promote adaptability and flexibility. Adaptation as part of higher level learning involves the proactive and innovative change of existing rules and norms in preparation for expected future conditions and

challenges. Sotirakou and Zeppou (2004) conclude that an organisation that executes higher level learning can be termed 'knowledge creating company' or as used in this thesis, 'learning organisation'. In an ideal model for organisational development, higher level learning enables individuals to realize the relationship between their personal responsibilities and the goals of the group, i.e. a generative learning approach stimulates self-reliance among organisational members to actively engage in new knowledge creation. It seems reasonably to conclude that in order for an organisation to engage in higher level learning there would be a requirement for second generation knowledge management.

The conclusion that lower and higher level learning are supported by first and second generation knowledge management, respectively, is underpinned by the argument by Pun and Nathai-Balkisson (2011) who argue that knowledge management and learning cannot be separated from each other. Sanchez (2004) concludes on a hybrid design that synthesizes the right combination and balance of both explicit and tacit knowledge for a company to achieve a competitive market position. To do so, companies need to engage both, lower and higher level learning, to optimise the creation and usage of explicit and tacit knowledge.

Besides the distinction between lower and higher level learning, Crossan *et al.* (1999) investigate how learning evolves from the individual to the organisational level. The approach by Crossan *et al.* (1999) is very similar to Nonaka's (2004) 'spiral of organisational knowledge creation', that underpins the strong link between organisational learning and knowledge management. As summarised in Table 5-3, they present a procedure that encompasses the four distinct sub-processes *Intuiting*, *Interpreting*, *Integrating*, and *Institutionalising*. Arguing that learning within the learning organisation passes through three aggregation levels, learning begins at the individual level, then aggregates to the group level, and ends up at the organisational level.

The links between experience, knowledge and consciousness are complex and intuition is often the beginning of learning at which tacit knowledge at the individual level can be developed. *Intuition* supports the exploration of noticed changes in the environment and provides information to be analysed on consciousness. The sub-process *Interpreting* enables the translation of observed changes in developed patterns into individual cognitive maps. Together with other organisational members a common language can be agreed upon the new situation and the importance at the individual and group level can be assessed. Castaneda and Rios (2008) term this dialogue between group members 'conversation' and argue that 'social

modelling' facilitates the process of understanding by modelling different patterns to general rules and a broader picture.

Level	Sub-processes	Outcomes
Individual	Intuiting	Experience
		Seek information
		Images
	Interpreting	Language
Group		Conversation/dialogue
		Social modelling
	Integrating	Shared understanding
		Mutual adjustment
		Interactive systems
	Institutionalising	Routines
		Diagnostic systems
Organisation		Rules and procedures

Table 5-3: Learning process from the individual to the network level
Source: adapted from Crossan *et al.* (1999)

At the group and organisational level, *Integrating* combines different angels on the changes in the individual and business environment to build up an organisation's knowledge base. At the top organisational level, routines, structures to store organisational memories, and rules that leverage the learning process can be designed. This *Institutionalisation* process also means to administer explicit organisational knowledge and to invest in information systems and infrastructure that enable a formalised integration of individually gained knowledge on local changes in the environment to the corporate adaptation strategy (Crossan *et al.* 1999). The following sections discuss individual and organisational learning in more detail.

5.4.2 Individual learning

According to Crossan *et al.* (1999, p. 526) *Individual learning* involves *"perceiving similarities and differences – patterns and possibilities".* Stonehouse and Pemberton (1999, p. 136) argue that *"the individual learning process is accelerated and enhanced by the sharing of information and knowledge accompanied by an openness that encourages questioning, debate, and discussion of existing practices".* Haugh and Talwar (2010) say that learning refers to the transmission of knowledge from one context to another and that individuals reshape their mental models and maps to take account of new information. In this context, Kim (1993) introduces the Observe-Assess-Design-Implement (OADI)-Cycle of Individual Learning as shown in Figure 5-3.

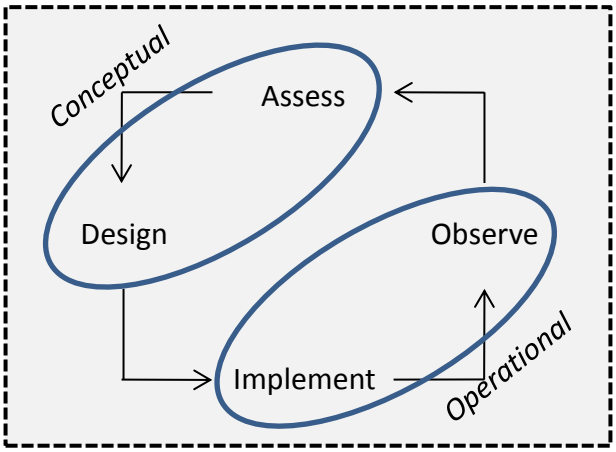


Figure 5-3: The Observe-Assess-Design-Implement-Cycle of Individual Learning
Source: adapted from Kim (1993)

Each phase refers to a particular stage of individual learning and begins with the experience and actively observation of concrete events at the operational level. Zietsma *et. al* (2002) argue that individuals not only learn from experience, but also from 'attending' and 'experimentation'. Attending is a conscious process of learning and refers to actively seeking information from the environment; experimentation means adding substance to cognitive interpretation through the results of experiments and taken action. In the conceptual phase, people begin to assess consciously or pre-consciously their experience, interpret observed information and develop individual tacit knowledge (Kim 2004). Based on these interpretations, appropriate concepts are designed in response. Kim (1993; 2004) describes the interdependence between the individual learning process and mental models and concludes that making mental models explicit is crucial to developing new and shared mental models. Senge (1990) argues that mental models can be described as people's internal images of how they see the world and therefore impact significantly on the individual behaviour and creation of tacit knowledge. In Kim's (1993) learning model, metal models encompass conceptual *frameworks* that impact on the design stage, and operational *routines* that influence the implementation stage in the OADI-cycle.

5.4.3 Organisational learning

The concept of organisational learning can be described as the activity or process of learning and has its roots in the well-known book '*Organizational Learning: A Theory of Action Perspective'* by Argyris and Schön (1978). It refers to *"a process of improving actions through better knowledge and understanding"* (Fiol and Lyles 1985, p. 803). Montuori (2000) states that organisational learning transfers individual learning toward system thinking which

prepares the organisation for adaptation to the environment. In particular *"organizational learning is a most noteworthy example of 'systems thinking in action'"* (Montuori 2000, p. 66). She further concludes that organisational learning will have taken place when adaptation to a changing environment happened. From a strategic perspective, Crossan *et al.* (1999) take the position that renewal of the entire company or network is the underlying phenomenon of organisational learning which aims to harmonize the trade-off between continuity and the need for change to retain at the competitive edge. From a knowledge-based perspective, Bierly *et al.* (2000) argue that organisational learning implies the creation and integration of knowledge. Corporations should aim to become a learning organisation to exploit the knowledge base (Senge 1990). Accordingly, organisational learning aims to strengthen a company's market position by collecting superior knowledge from different sources and optimise critical business areas by integrating different acquired knowledge into the organisation. Pun and Nathai-Balkisson (2011) argue that knowledge management evolves to higher-order organisational learning when organisations progress from lower level learning to higher level learning. Achieving higher-order organisational learning, Simon (1991) states that the transmission of information and knowledge from one organisational member to another is key to organisational learning and that it is important to determine where in the organisation particular knowledge is stored and who has learned it. Hedberg (1981) declares that organisational learning occurs through individuals who shape the organisations' views and ideologies through personalities, personal habits, and beliefs. Kim (1993) takes on this perspective and presents an "Integrated Model of Organisational Learning" as illustrated in Figure 5-4.

The model is built on the OADI-cycle and illustrates the interdependence between individual, organisational, single- and double-loop learning. The OADI learning process and the developed mental models at the individual level shape the concepts and operational routines at the organisational level. As part of this double-loop learning process, individuals challenge their existing knowledge base, create new tacit knowledge and are encouraged to translate it into explicit knowledge to share it with other members at the organisational level. Accordingly, organisational activities and the explicit knowledge base are shaped through individual and organisational double-loop learning and result in rules setting and target processes for all organisational members to be implemented at the individual level. The integrated model of organisational learning clarifies that individual learning provides key information such as understood changes in the environment and responding adaptation ideas to the organisational

level. Organisational activities design corporate adaptation plans and monitor their implementation at the individual level.

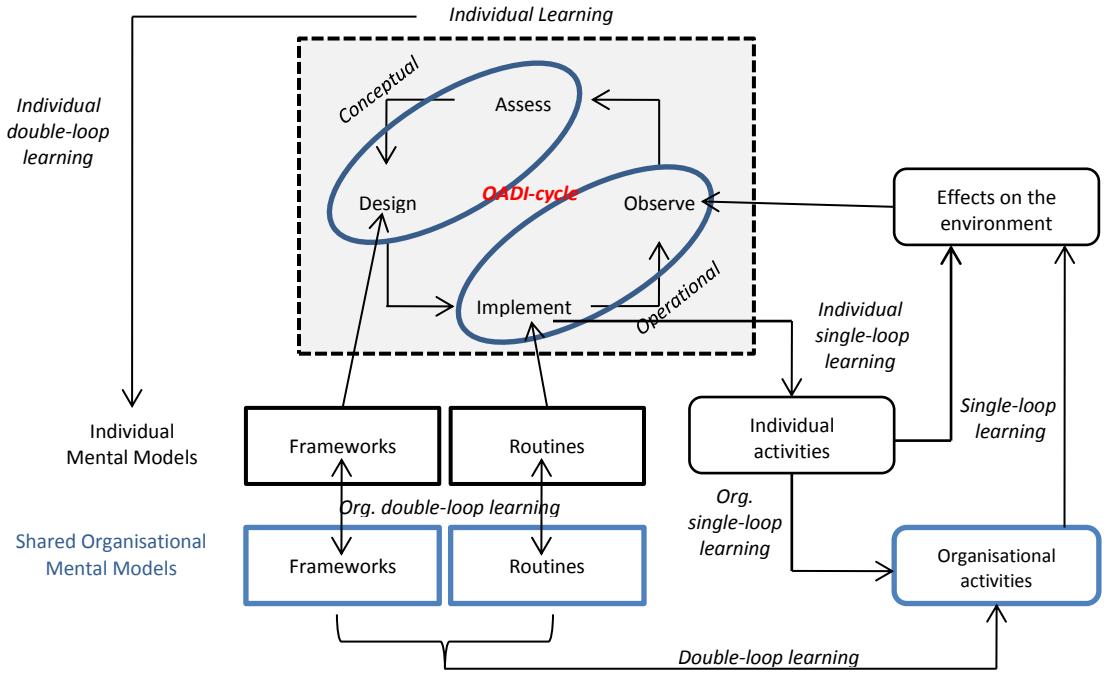


Figure 5-4: Integrated Model of Organisational Learning
Source: Kim (1993)

Both, at the individual and organisational level, double-loop learning facilitates the creation of up-to-date knowledge that is continuously transferred between the different entities within an organisation. As a result, organisational concepts and routines can be implemented and challenged for improvement by all individuals. Besides double-loop learning, Kim`s (1993) model also integrates the concept of single-loop learning to enable individuals the continuous improvement of their daily routines.

Although organisations learn through their members, Hedberg (1981) argues that organisational learning is not the cumulative result of the members' learning. As members come and go, organisations need to put in place cognitive systems and memories to preserve certain behaviours, norms and values over time. Adding to this view, Simon (1991) argues that individuals are part of a society and learn 'within a community of practice', i.e. it might be more precise referring to collective learning instead of individuals or organisations. He also argues that learning is situated as stored up-to-date explicit knowledge within the organisation might have another meaning in a different situation in the future. Moreover, Lucas (2010) argues that individual knowledge can only become organisational knowledge if employees are

willing to share their tacit knowledge throughout the organisation. He discusses possible difficulties in sharing knowledge and argues that particularly two problems hinder organisational knowledge distribution. First, new knowledge can squeeze out existing organisational knowledge in an unstructured process. Therefore, organisations could apply the concept of unlearning, which is consciously eliminating knowledge that is no longer considered as relevant for the future organisation (Hedberg 1981) to actively design the organisation's competitive knowledge base. Second, relevant knowledge, particularly tacit knowledge that is already part of the organisation must be protected against competitors as free access to knowledge makes imitation possible. For that reason, organisations need to create a structure in which employees make use of their knowledge for the benefit of their organisation, but deny access to this important knowledge for organisational outsiders.

However, even the best learning structures do not guarantee competitive advantage. Bierly *et al.* (2000) argue that the acquisition of more and more information and knowledge does not necessarily lead to greater business success as organisational knowledge is not always translated into strategic choices for decision makers to improve the business. Accordingly, knowledge of climate change does not necessarily mean that organisations will use that knowledge. Referring to this difficulty, Bierly *et al.* (2000) introduce the concept of organisational wisdom and investigate the hierarchical relationship (Pun and Nathai-Balkisson 2011) between data, information, knowledge and wisdom as part of the organisational learning process. They argue that information gives meaning to raw facts and makes data useful by giving it form and functionality. In turn, knowledge means a clear understanding of information through analyses and syntheses. Individual wisdom involves personal judgement, spirituality and passion. Wisdom is an action-oriented concept and can be defined *"as the ability to best use knowledge for establishing and achieving desired goals"* (p. 601). Wise people therefore not only hold justified true beliefs and knowledge, but use their intellectual power to practically apply it. As business success significantly relies on managers' decisions, they take the position that wise executives are likely to make better decision than just knowledgeable executives as they inspire greater loyalty and trust. Even if organisations have great capabilities to seek out information, make sense of it and generate knowledge as part of organisational learning, they need to be wise and transfer gained organisational knowledge into appropriate organisational strategies and operational actions. In other words, organisations could be knowledgeable, but not wise and therefore lack a competitive advantage as they fail to make the most out of their knowledge they possess. Organisational wisdom can be achieved by using knowledge to set and achieve goals and by diffusing

individual wisdom to the organisational level through transformational leadership, appropriate organisational culture and structures, and knowledge transfer throughout the organisation.

Bhatt (2000b) further investigates the link between individual and organisational learning and presents an 'Individual-Organisational-Learning' matrix. He argues that within a company, individual and organisational learning capabilities can be developed to varying degrees which result in four different learning states of a firm as shown in Figure 5-5.

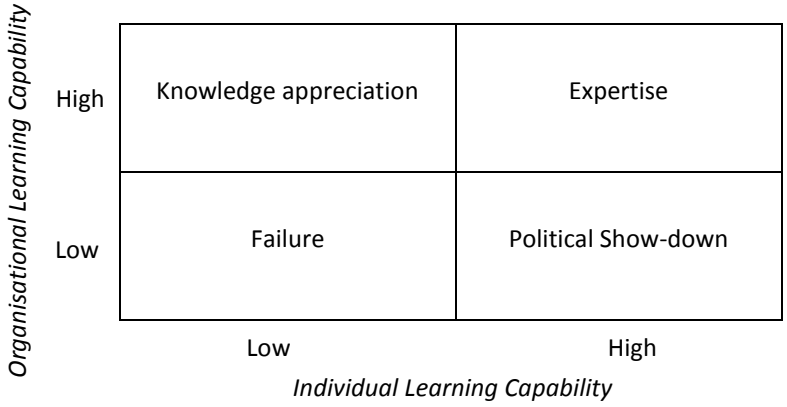


Figure 5-5: Individual-Organisational Learning matrix
Source: adapted from Bhatt (2000b)

Each quadrant of the matrix is explained as follows:

- **Failure:** This quadrant represents the most unsatisfactory condition for a company, as neither an individual nor the organisation have an appropriate attitude towards learning. Their learning efforts are low and it is likely that organisations will not survive. Their failure to exist will be caused by an inappropriate knowledge base and lack of capabilities to create new knowledge.
- **Political Show-down:** The organisational culture is considered unfavourable for learning. However, individual learning is quite high leading to the conclusion that organisations fail to appreciate the knowledge of its members. Poor management at the organisational level may lead to increased vulnerability of the firm due to a rise in conflicting strategies and personal rivalry. As a result, employees with important tacit knowledge may leave the organisation and put the firm in a position in which there is no or little learning at the organisational level, and eventually at the individual level as well. Accordingly, firms are in danger of degrading to the failure quadrant.

- **Knowledge appreciation**: Despite the fact that organisational culture is considered highly incisive to learning, individuals within the organisation posses poor learning capabilities. As a result, individual learning is slower than organisational learning. Consequently, there is strong organisational emphasis on internal and external employee training and knowledge sharing with other organisations. Under these conditions little valuable tacit knowledge is created.
- The best conditions for a firm's success are represented by the **Expertise** quadrant. This symbolizes the preferred status to achieve competitive advantage as organisational culture is considered favourable to learning and the capability for individual learning is also high. The link between knowledge creation and learning capability leads to a continuous flow of information, ideas, and knowledge sharing among the members within the organisation. Nonaka (2004) argues that particularly the critical notion of externalization, i.e. the conversion of tacit knowledge into explicit knowledge, is important to achieve the state of a learning organisation. Knowledge from different sources is generated and newly combined at the organisational level. It allows the organisation to be innovative and enhance its market position by constantly developing novel patterns and expanding its own knowledge base. This state of a firm is one of the key objectives of a learning organisation. Therefore, it is reasonable to conclude, that Bhatt's (200b) expertise learning state reflects Kim's (1993) integrated model which prioritises a route to organisational learning.

5.5 Learning at inter-organisational network level

Today it is widely accepted that inter-organisational networks either support or hinder organisational learning processes and outcomes. Acknowledging the hierarchically order of system levels including the individual, group and organisational levels, this thesis recognises the 'inter-organisational network' level as the fourth level of learning (Knight 2002). Research that combines the two concepts of 'learning' and 'network', needs to initially clarify the understanding of 'network learning'. Knight (2002) presents two schools of how network learning can be researched: a) by focusing on learning of organisation within networks (inter-organisational learning), i.e. a network is the context for learning of network members; and b) by applying a network-centred view that investigates learning by networks (network learning), i.e. the network is the learner. Referring to the former case, inter-organisational learning researches how each organisation can improve its competitiveness and derive private benefits from the interaction with other organisations that are part of the network. In turn, network learning can be defined as "*learning by a group of organizations as a group*" (Knight 2002, p.

428) with the objective to learn from one another and through the interaction of member organisations. The concepts of inter-organisational learning and network learning are discussed in further detail in the following sections.

5.5.1 Inter-organisational learning

Stonehouse and Pemberton (1999) take the position that inter-organisational learning arises from creating accelerated synergies between linked organisations through shared knowledge and competencies. Pena (2002) takes the knowledge perspective and defines a knowledge network as *"an inter-organisational agreement to share knowledge among members for the exploration (i.e. creation and development) or exploitation (i.e. product transformation and commercialization) of new technologies"* (p. 472). He argues that besides improving internal knowledge capabilities, organisations should strengthen their external links within the network to integrate partner's skills and knowledge. Such external links could either be horizontal or vertical. Whereas horizontal knowledge networks aim to strengthen and intensify an industry's knowledge base and benefit from synergy effects within the same sector, vertical knowledge networks have the objective to acquire capabilities, knowledge and critical functions from other organisations at different value adding levels along the supply chain (Pena 2002). Independently of horizontal or vertical links, organisations restrict access to valuable information as long as they decide not to take part in an inter-organisational network and are willing to share knowledge throughout the network. It can therefore be concluded that organisations only take part in inter-organisational learning if they see a benefit for their company.

However, Pena (2002) also identifies uncertainty as a major handicap for collaboration in knowledge networks. Moreover, Holmqyist (1999) refers to the problem that organisational partnerships are often non-linear and are embedded in networks in which partners can be part of different supply networks. Therefore, he further argues that learning in contemporary partner collaborations takes place without boundaries. Thus the organisations within a particular network may have the same information, but not necessarily the same knowledge of an issue. For that reason, Srivastava and Frankwick (2011) argue that the positive attitude of top management towards learning and information sharing is crucial to the adaptation process of the entire supply network. Similarly, Knight (2002) argues that personal capacity to collaborate is a highly important factor that is however also highly vulnerable to change. Particularly, a key objective of inter-organisational learning is the acquisition of tacit knowledge from partners within the network that is either held at the individual or organisational level (Holmqvist 1999). By discussing the different organisational knowledge

bases, partners are encouraged to reflect tacitly held knowledge and to articulate it into explicit knowledge for the benefit of the partners in the inter-organisational learning process.

5.5.2 Network learning

A network can be understood as a form of organisation in which legally independent agents are linked via collaborative work and interdependent resources and activities (Ebers 1997). In the context of organisational research, Knight (2002) concluded that a network can take four different forms: a) intra-organisational networks (legal entity with different relatively autonomous sub-units); b) network organisations with a high degree of vertical and horizontal integration via socially important relations; c) strategic networks which are a group of autonomous, but interdependent and cooperating organisations; d) loosely bound collectives of organisations "*linked by geographical proximity, similar interest or activities, or participation in the production/delivery of a product or service*" (p. 430). This thesis focuses on the two latter types as the investigated case includes elements of both forms as explained in chapter 8.

Considering Kim's (1993) integrated model of organisational learning, network learning creates co-ordinated practices and shared interpretations and norms to impact organisational mental models and cognitive structures to result in changed outcomes of learning (Crossan *et al.* 1995). Similarly, Knight and Pye (2004) conclude that network learning is indicated by "*changes in properties of the network (practices, structures and interpretations) that shape and are shaped by network actors, their actions and interactions"* (p. 485). Yet, the research on network learning by Knight and Pye (2004) is rather conceptual in nature and focuses on the activities that help to create a multi-level understanding of network processes, but does not explore how 'created network knowledge' leads to changes and adaptation of organisations or the network to a changing environment. This limitation is underpinned by their finding that learning outcomes are not the net change in terms of performance, e.g. adaptation, but rather result in changing practices and structures that may then later enable change.

To distinguish between the different concepts of organisational learning, inter-organisational learning and network learning, Knight (2002) combines the level of learning as well as the context of learning as illustrated in Table 5-4. According to this matrix, network learning occurs at the fourth learning level, *network,* and is influenced by organisational behaviour and performance as well as inter-organisational activities. However, as already established learning in this thesis includes *adaptation,* needed to actually achieve a change in existing processes and structures, the outcome and success of network learning should therefore also be influenced by organisational learning and implementation capabilities.

	Context of learning	
Level of learner	**Organisational**	**Inter-organisational**
Organisation	Organisations learn through intra-organisation interaction	Organisations learn within networks
Network	Network's learning is influenced by an organisation	Networks learn through intranetwork interaction

Table 5-4 Cross-tabulation of level of learner and context of learning
Source: adopted from Knight (2002)

To illustrate network learning, Knight and Pye (2005) present a model of network learning that is context specific, i.e. it is dependent on purpose, actors, operations, etc…, and focuses on conceptual themes such as network structures, practices, and interpretations. The third element of their concept addresses the learning process that focuses on the development and change of meaning, commitment, and method which shape the learning outcomes. However, the learning outcomes might not be distributed uniformly throughout the network and might be differently applied at the organisational level despite their general nature overall. For that reason, the authors refer to the principle of learning episodes which allow networks to punctuate their learning process and evaluate and apply the outcomes achieved.

Considering the complexity of a network that underlies strong dynamics in interdependencies between agents and resources, as discussed in the following section on complex adaptive systems, Knight and Harland (2005; 2001) emphasize on the need for network management to organise network learning. They define network management as "*generating and coordinating inter-organisational co-operation*" (2005, p. 281) and conclude on six management roles to intervene and enable supply networks to learn. Each role is described as follows:

- *Innovation facilitator* - promotes products, services and process innovations, and facilitates the integration of new processes, structures, and interpretations into the existing ones;
- *Co-ordinator* - manages inter-organisational activities by facilitating intra-network relations, communications, and working practices. This function is likely to be resource intensive to co-ordinate all agents, information, projects, and finances
- *Supply policy maker and implementer* - responsible to determine the general direction and key objectives of the network learning process and to ensure the implementation of such policies throughout the network at the macro- as well as micro-level (organisations).

- *Advisor* - an expert with specific knowledge in the context of the supply network in order to assist network members in the learning process. This role requires a strong track record and credibility before an organisation is accepted in this function.
- *Information broker* - collects, analyses and disseminates information and data to the network members. A proper communication tool is required and a transparent flow of information.
- *Network structuring agent* - influences and aligns the structures and processes of the interrelationships and interactions between network agents to facilitate the network learning process.

The field research therefore needs to consider these roles when designing a network learning process that enables supply networks to adapt to the impacts of climate change, particularly as supply networks are not static constructs, but rather complex and messy as discussed in the following section.

5.5.3 Inter-organisational network learning in complex adaptive systems

In a globalised world with open markets, new thinking has evolved that organisations should be viewed as complex systems in a dynamic environment (Desai 2010). Organisational complexity has been increased rather than reduced (Palmberg 2009; Espinosa and Porter 2011) and therefore requires a system thinking approach that challenges the underlying structures to generate sustainable adaptation of the entire network an organisation is part of (Senge 1990). McElroy (2000) investigates inter-organisational network learning in the context of a dynamic environment and argues that *"complex adaptive systems (CAS) theory offers a very clear explanation of how knowledge naturally unfolds and evolves in human organisations [...] and how learning and innovation happen in living systems"* (p. 202). However, as complex systems are not always complex adaptive systems, Desai (2010) and Choi *et al.* (2001) argue that *agency,* which is *"the ability to intervene meaningfully in the course of action"* (Desai 2010, p. 391), makes a complex system a complex adaptive system. Choi *et al.* (2001) describe a complex adaptive system (CAS) as an interrelated network with many agents that focuses on the co-evolution of the network with the environment, and that facilitates adaptation of the agents and the network to the environment. Nilsson (2003, p. 22) adds to this definition that the agents in a CAS *"are responsive, flexible, reactive, and often proactive regarding inputs from other agents or elements that affect them"*. This argument aligns with Allen and Strathern (2003) position that network learning needs to consider the complexity of networks as *"almost no improvements can be made assuming ceteris paribus (all other things remaining the same), because many attributes are emergent properties that arise from the interacting components*

that make them up" (p. 28). It can therefore be concluded that the network learning process about the impacts of climate change needs to consider changing network structures that emerge as a result of these impacts and the responses thereto. In the context of an altering environment, Scot (1987) similarly argues that CAS reinforce the exchange of information and feedback particularly with the external environment and Tilebein (2006, p. 1088) concludes that CAS are able to *"emergently change, adapt and (co)evolve in harmony with their changing environment".* Kaufmann (1995) emphasises on the competitive edge that possibly emerges from a changing environment and notes that CAS evolve with the environment through the self-organising behaviour of agents navigating the 'fitness landscape' of market opportunities. With reference to the self-organising element, CAS can be distinguished from traditional hierarchy processes in decision making in two ways: First, CAS involves bottom-up structures instead of predominately top-down management approaches (Espinosa and Porter 2011; Tilebein 2006). And second, the causality of decision making is usually non-linear in a complex network as the different agents across the network are connected unsystematically (Wulun 2007).

In summary, CAS are based on the idea that organisations co-evolve together with their environment and enable the implementation of adaptation strategies as part of the learning processes at organisational and inter-organisational level in a rapidly changing environment. Complex adaptive systems theory therefore assumes that complexity is the result of interacting agents; that order is the natural result of non-linear interactions whereby behaviour creates structures; and that systems are regarded as dynamic processes (Nilsson and Gammelgaard 2012).

5.5.4 Inter-organisational network learning in complex adaptive supply networks

The research by Pathak *et al.* (2007) revealed that the CAS theory attracted a lot of research areas such as industrial engineering, computer science, physics, organisational science, and strategic management, but falls short when integrating the principles of CAS into SCM research. Varga *et al.* (2009) argue that supply networks have matured through a number of stages involving the concepts of supply chain management, integrated business networks, and demand chain communities. They add to perceive supply networks as complex adaptive systems and argue that in 'complex adaptive supply network' coevolution *"occurs between the firms and the supply network, in the context of the environment"* (p. 17). Yet, despite this evolutionary development process, only a handful of scientists (e.g. Hearnshwa and Wilson 2011; Wysick *et al.* 2008; Ellram *et al*. 2007; Pathak *et al.* 2007; Surana *et al.* 2005; Nilsson and Darley 2006; Nilsson 2003, etc…) have conducted research on CAS in the context of SCM and

logistics since the pioneering paper by Choi *et al.* (2001). They formed the term *complex adaptive supply network* (CASN) and describe it as *"a collection of firms that seek to maximize their individual profit and livelihood by exchanging information, products, and services with one another"* (Choi *et al.* 2001, p. 365). Pathak *et al.* (2007, p. 562) view CASN as *"a system of interconnected autonomous entities that make choices to survive and, as a collective, the system evolves and self-organises over time".* Given the latest definition of CASN, the concept of adaptability can be linked to the concept of resilience in risk management theory which aims to reconfigure connectivity to fit new changing environmental conditions to survive. Effective adaptability therefore decouples from older structures and principles and is permanently open to new formations of relationships throughout the network (Hearnshaw and Wilson 2011). However, relationship building is difficult and the concept of network learning in CASN therefore needs to consider the complexity and dynamism that underlie the group as a learner. For example, Nair *et al.* (2009) emphasised the importance of inter-relationships within CASN and concluded from their empirical research on the need to identify the 'cooperating-inducing incentive structures'. Organisations might therefore not participate in the collaborative network learning process even though they expect a positive return. Indeed, the organisational benefit might be perceived as lower in comparison to the payoff the organisation will receive if it does not take part in network learning.

As the focus of this thesis is however to investigate how supply networks can adapt to climate change through organisational and inter-organisational network learning, it does not aim to extend the literature on complex adaptive systems and deepen its cause and effect relationships. Accordingly, the objective is not to investigate the *"fundamental relationships among structure, performance, and environment"* (Davis *et al.* 2009, p. 416) in a supply network, but rather to reveal the network learning process that enables adaptation considering that a supply network is not a static construct, but complex and dynamic. Therefore, this thesis refers to the fundamental conceptual framework of CASN as introduced by Choi *et al.* (2001) that involves three key components: *Internal Mechanisms*, *Environment*, and *Co-Evolution*. Representing the underlying dynamics of a CASN, *Co-Evolution* describes bilateral dependencies and bridges between the external *Environment* that influences on the supply network, and in this thesis is referred to as climate change, and *Internal Mechanisms,* as referred to as learning at organisational and inter-organisational network level, that enable CASN to adapt to changes through managerial implications. Each component is described as follows:

Internal Mechanisms

Internal Mechanisms refer to the ability to design and manage a CASN. With reference to Stonehouse and Pemberton (1999) an intelligent and learning network needs to have members with good leadership qualities and must design proper (inter)-organisational structures and communication channels. The internal mechanisms and managerial elements describe how involved employees should behave to create an organisational climate that facilitates the adaptation of the supply network through changes in organisational structures and management approaches. And although not every emergent adaptation increases a system's chance of survival, a CASN produces variations in existing structures which can lead to long-term survival and competitive advantage (Espinosa and Porter 2011). Choi *et al.* (2001) distinguish between four internal elements: *Agents, Self-Organisation and Emergence, Network Connectivity,* and *Dimensionality*. Each factor can generally be described as follows and is presented in the context of climate change and learning in the next chapter:

a) *Agents* are the core elements of CAS and are individuals or organisations that interact with another. They behave in a manner as to increase fitness of the system they belong to and have agency to actively intervene meaningfully and shape the systems' structure and strategy. Choi *et al.* (2001) note, that agents collectively form a system's schema, i.e. norms, values, beliefs and behavioural rules in a network. Stonehouse and Pemberton (1999) and Palmberg (2009) conclude that each CASN should have a leading system holder who manages the CASN.

b) *Self-Organisation and Emergence* means that CASN *are* self-organising through simultaneous actions of their agents and generate new emergent structures and patterns without necessarily being externally imposed. Espinosa and Porter (2011) say that the principle of self-organisation requires conditions where cross-channel communications is unhindered. They argue that self-organisation creates a condition of tension and instability to keep pressure for innovation, imagination and change without exceeding people's ability to handle the stress put on. Therefore, the behaviour of a CASN is emergent as it facilitates bottom-up processes of idea generation, progressing to initiative development, trial projects, and adaptation of new innovations. Emergence also means to create new and stronger attractors for agents as the ones in place to change something and support the self-organising process (Espinosa and Porter 2011).

c) *Network Connectivity* determines the complexity of a network whereas the number of weak links across the network affects the ability to adapt. Tielebein (2006) discusses internal and external links of a CAS and argues that the number of internal links

between agents measures a system's internal complexity. Firms can actively design internal complexity by reducing or adding internal links. *"When an agent's properties are coupled via internal links, their contributions to the agent's overall fitness are not independent; in this way a change in one property can affect fitness contributions of others"* (p. 1093). Internal links refer also to the aggregation of agents in the form of department, business units or networks. Tilebein (2006) argues that it is a crucial management task to form organisational structures above temporary structures as a result from self-organisation. External links connect the network to the environment and enable coevolutionary dynamics between both, the network and the environment. The proper design of external links either facilitates or hinders co-evolution and eventually rapid adaptation.

d) *Dimensionality* can be defined as *"the degree of freedom that individual agents within the system have"* (Choi *et al.* 2001 p. 354). They argue that too much control reduces dimensionality while autonomy of agents increases dimensionality. On the one hand, CASN aim for diversity which evolves from learning and self-organisation when agents adapt individually to their local environment (Tilebein 2006). On the other hand, CASN must remain manageable and usually have few dominant agents to decide on the schema and structure. Choi *et al.* (2001) argue that an increased level of closer collaboration in supply networks results in a higher level of fitness through reduction in transaction costs and increase in communication efficiency, and eventually results in efficient and effective adaptation. However, Desai (2010, p. 397) takes the position that *"greater level of shared schema among agents reduces diversity of ideas, productive fictions and tensions within CAS, and thereby, it resists appropriate functioning of CAS"*. Davis *et al.* (2009) address this trade-off between efficiency and flexibility, and conclude that it is well established in literature that dynamic environments require much organisational and system structure whereas too much control constraints flexibility. Even though they argue that this trade-off should be between less structures that open for new unanticipated opportunities and more structures that execute anticipated opportunities more efficiently, Davis *et al.* (2009) agree with the viewpoint that the balance between both extremes is significant for organisational and network performance in dynamic environments. Therefore, Tilebein (2006) suggests to implement action rules that describe information processing procedures between interacting agents, i.e. who requires what kind of information from whom to determine the optimal 'edge of chaos' of CASN.

Environment

The environment exists external to CASN and involves agents that are not part of the network. Choi *et al.* (2001) argue, that the environment can be characterised as dynamic and rugged. A dynamic environment can impose new rules and patterns (i.e. schema) of the CASN, and can lead to adjustments of the CASN boundary, i.e. agents are included or excluded and connections between these agents are added or eliminated. A rugged landscape describes the potential of the surrounding environment of a system whereas the highest point in this virtual landscape may represent the optimal state of the environment for the CASN. Rugged landscapes refer to an environment in which the optimum is not evident and depends on tightly coupled components that influence each other. The dynamism of the environment frequently reshapes the landscape and forces CASN to exploit existing and new knowledge to overcome the uncertainty caused by a changing environment (Choi *et al.* 2001). A rugged landscape makes it also difficult to determine the overall goal of the CASN in response to the changing environment. Tilebein (2006) refers to goal setting as determining the fitness landscape, which involves a performance measurement system for each agent and the entire CASN to evaluate the success of the adaptation process to a rugged and dynamic environment.

Co-evolution

Choi *et al.* (2001) argue that CAS react to and generate the environment, and that co-evolution refers to the mutual creation of dynamic and emergent realities. It is based on the idea that the environment forces changes in CAS which in turn trigger changes in the environment. Alan and Strathern (2003) argue that evolution implies the idea that emergent capabilities that arise in complex systems will pull the energy and maters necessary to maintain new structures. Accordingly, feedback from the environment facilitates new structures for competition, cooperation and utilization of the same resources within the CASN and affords new adaptation approaches. Espinosa and Porter (2011) argue that co-evolution supports the formation of collaborating networks that focus on promising innovations and allow for experimenting to produce new solutions. Bridging between 'Internal Mechanisms' and 'Environment', co-evolution involves the three elements *Quasi-equilibrium and state change, Non-linear changes,* and *Non-random future* that describe processes and conditions under which 'Internal Mechanisms' and 'Environment' converge. Quasi-Equilibrium is a state in which a CAS usually balances between maintaining order to favourable patterns and reacting to a changing environment by switching to newly developed behaviour (Choi *et al.* 2001). This balance point is also referred to as 'edge of chaos' which can be described as transition phase between order and chaos (Palombo 1999). This state of bounded instability (Palmberg 2009) generates

tension within the network and enables the shift of productive energy to key problems that might be triggered by external changes impacting on the network and pushing it far from equilibrium (Espinosa and Porter 2011). Choi *et al.* (2001) make clear that it is difficult to precisely predict how a system will develop in the future. They conclude that CASN have not centralised structures, but are predominately based on non-linear relationships to rapidly react to non-linear changes. Already small changes in the environment can cause significant damage to a sensitive network, as *"a direct correlation between the size of cause and the size of the corresponding effect is not guaranteed"* (p. 357). The non-linearity of CAS requires rules that sanctions conversations across boundaries and avoid detailed instructions to embrace individual freedom (Espinosa and Porter 2011), but that also maintain the ability to manage and adapt CASN.

5.6 Summary

In summary, learning is a concept that seeks to understand and adapt to a changing environment of humans and businesses, and that can take place at the individual, organisational, and inter-organisational network level. The literature in learning is strongly related to the theories in knowledge management and integrates the concepts of explicit and tacit knowledge and can take two different forms of lower level learning (related to first generation knowledge management), and higher level learning (related to second generation knowledge management). As every organisation learns through its members, the concept of 'the learning organisation' has emerged to describe the conditions that help a company to adapt to the identified changes. However, organisations are usually part of supply networks that require inter-organisational learning to respond to changes that impact the network as a whole. The reviewed literature clarified the distinction between inter-organisational learning *within* networks, i.e. organisations learn though interaction with others for their own benefit; and inter-organisational learning *by* networks which is referred to as network learning and means to learn as a group for the benefit of the whole system. Considering the nature of a network, it can reasonably be argued that learning at organisational and inter-organisational learning takes place in networks that are complex adaptive systems, or as in this thesis, complex adaptive supply networks (CASN). The next chapter therefore presents two *a priori* conceptual frameworks that integrate the literature on learning and complex adaptive systems in order to conclude on an overall learning process in the analysis chapter that enables supply networks to adapt to climate change.

Chapter 6: Development of research questions and conceptual models

6.1 Introduction

Integrating the different findings from the literature review and synthesising the key concepts from knowledge management and learning in the context of climate change, this chapter outlines the thesis' research structure to investigate the overall research aim (RA):

RA: The aim is to determine how supply networks can adapt to climate change and its related risk factors.

The first section addresses research objective 1 (RO1) and examines the current learning processes of organisations and inter-organisational networks relating to climate change risk. Referring to the hierarchy of learning levels, initially learning at the organisational level is investigated. The first *a priori* model addresses organisational learning and is based on the assumption that a network might adapt as a whole, if organisations have a high level of freedom and independency to individually adapt to a changing environment (*dimensionality*). However, assuming that organisational learning will not result in the adaptation of the supply network as a whole, learning at the inter-organisational network level is researched to reveal a process of network learning. The second *a priori* model therefore investigates inter-organisational network learning to enable adaptation of supply networks recognising the complex and dynamic environment. As most members of a supply network are for-profit organisations, first inter-organisational learning is researched to identify how organisations learn from other agents within a network. However, global supply networks may require the need to also learn as a group and therefore need to implement the process of network learning, such as in the case of an international programme, for example, to not only achieve immediate benefits for the single organisation, but to increase the overall resilience of the supply network as a whole (Knight and Pye 2004; 2005). Based on the findings relating to RO1, section two then addresses research objective 2 (RO2) and aims to determine and model the concept of network learning applicable to climate change risk. It deals with the questions of what the network learning process is and what enabling principles and mechanisms facilitate this process.

6.2 Research objective 1

To conclude on research objective 1, Simon's (1991) argument, that individuals are the learning entities within an organisation is extrapolated. It can therefore reasonably be argued that organisations are the learning entities in a supply network and that a supply network learns in only two ways: a) by learning of its members; and b) by ingesting new members who have learning abilities the network did not previously have. Accordingly, it can be concluded that a supply network learns and adapts, if each agent learns about climate change. As learning can take different forms and levels, a supply network is understood as a system of interrelated roles. For that reason, the following research question 1 (RQ1) has been developed:

RQ1: What type of learning enables companies and networks to adapt to climate change risk?

To investigate the different learning processes, first a conceptual framework to structure the research on organisational learning is presented. The second part of this section introduces the concept to investigate inter-organisational learning.

6.2.1 A priori conceptual model for organisational learning

In order to explore whether organisations learn about climate change, an *a priori* conceptual model is developed to frame the field research. The Oxford Precise Dictionary defines *a priori* as "relating to or denoting reasoning or knowledge which proceeds from theoretical deduction rather than from observation or experience", i.e. knowledge that is "in a way based on theoretical deduction rather than empirical observation". The *a priori* model structures the field research by integrating pre-existing categories into which collected data and information can be fitted (Sham 2007). Accordingly, the field research does not need to start from scratch. Instead, the "*a priori* specification of constructs can help to shape the initial design of theory-building research" (Eisenhardt 1989, p. 536). As shown in Figure 6-1, the model is designed as a learning cycle and refers to the two learning phases 'understand' and 'adapt'. The learning cycle is initially deployed to the organisational level and involves four different steps: 1) Knowledge absorption; 2) Knowledge transformation; 3) Knowledge utilization; and 4) Adaptation to a changing environment. Figure 6-1 illustrates that the environment impacts on the organisation and that supply chain climate risk is the input factor for the organisational learning cycle (OLC). Besides the primary aim to adapt the organisation to the identified environmental changes, the completion of the OLC may also result in a mitigating effect (e.g. reduction in carbon emission, etc…). In this context, mitigation refers to climate change mitigation and does not relate to mitigation as introduced in the chapter on risk management.

.

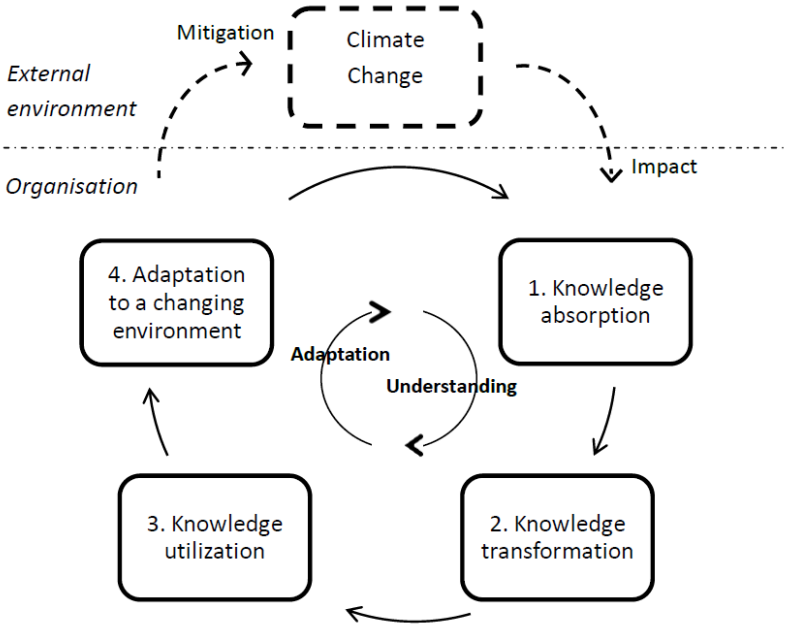


Figure 6-1: Organisational learning cycle

The presented *a priori* conceptual model considers Montuori's (2000) three efforts to achieve a learning organisation, i.e. understanding the business environment, strong employees' involvement and adaptation, and clear organisational structures and leadership. Stonehouse and Pemberton (1999) argue that the faster this cycle the greater the competitive advantage. Social knowledge management techniques enable this cycle to proceed more quickly and effectively so that an organisation adapts to a changing environment ahead of its competitors. Consequently, climate change, as a newly identified risk source requires fast organisational learning to fully understand and adapt to the projected environmental change. Each of the four learning steps is explained as follows:

<u>Step 1: Knowledge absorption</u>

As part of this step, information about environmental change is initially converted into individual tacit knowledge by members of the organisation. People begin to make up their mind and develop their individual mental models about climate change. From an organisation's point of view, it is important to develop a learning environment that encourages employees to create knowledge through observation, experimentation, knowledge transfer, and actively seeking information about a changing environment. With reference to Nonaka's (2004) spiral of organisational knowledge creation, this step particularly addresses the concepts of socialization and internalization. As a result, potential supply chain risks can be rapidly identified. Knowledge absorption about climate change at the individual level addresses Senge's (1990) disciplines 'Personal Mastery', 'Mental Models', and 'Shared Vision'.

Bui and Baruch (2010) argue that the three outcome factors *Individual performance, Self efficacy,* and *Work-life balance* can provide evidence for knowledge absorption. In order to provide such evidence, the field research needs to investigate Bui and Baruch's (2010) presented antecedents towards climate change that enable and influence each of the three outcome factors as illustrated in Figure 6-2. Based on Bui and Baruch's concept, six antecedents that enable knowledge absorption about a changing environment have been set up. In particular, each of the antecedents relates either to the individual person or to the entire organisation and explains a detailed facet that fosters knowledge absorption. For that reason, organisations should aim to simultaneously design and support all six antecedents to encourage people to understand their environment and to be able to identify potential supply chain risks.

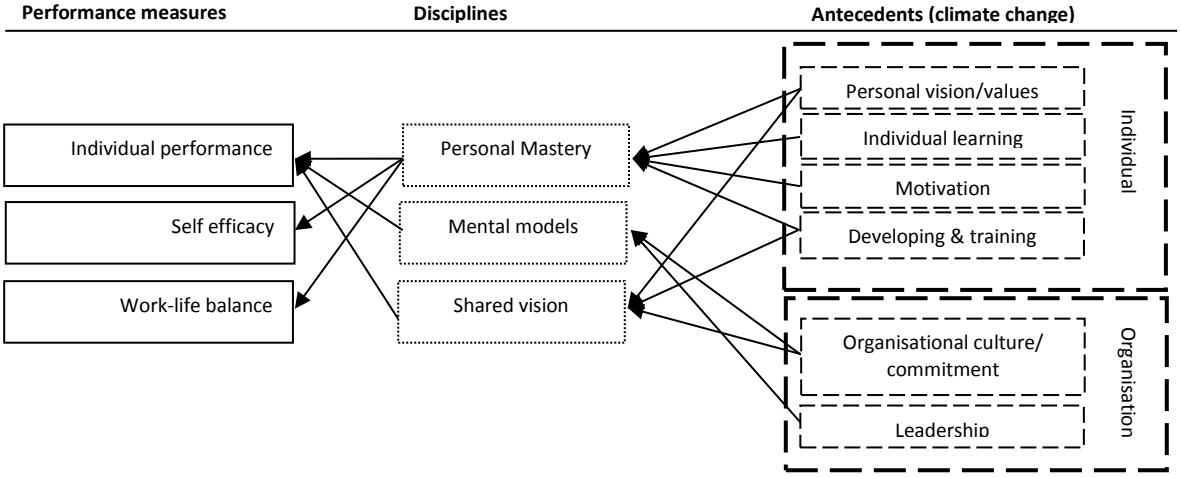


Figure 6-2: Disciplines and antecedents that facilitate 'knowledge absorption'
Source: adopted from Bui and Baruch (2010)

Step 2: Knowledge transformation

In this step, individual knowledge is transformed into organisational knowledge. Organisations aim to convert valuable tacit knowledge into explicit knowledge to share it among employees within the organisation. Accordingly, these critical activities refer to Nonaka's (2004) concepts of externalization and combination. Knowledge transfer, as part of first generation knowledge management, enables employees to benchmark their current processes and to identify the best practices in daily routines. As part of second generation knowledge management, knowledge transformation would enable the analysis of supply chain climate risk. Knowledge of environmental changes gathered from globally dispersed subsidiaries should be transferred throughout the entire organisation. To build a global picture of the location and intensity of all

SCCR, all created knowledge needs to be distributed throughout the organisation. As shown in Figure 6-3, five antecedents at the group and organisational level impact the company's ability to transform knowledge between all members. In order to remain at the competitive edge, organisational structures need to include appropriate communication systems and should create a learning environment that facilitates employees' trust in the company and the willingness to collaborate with other people.

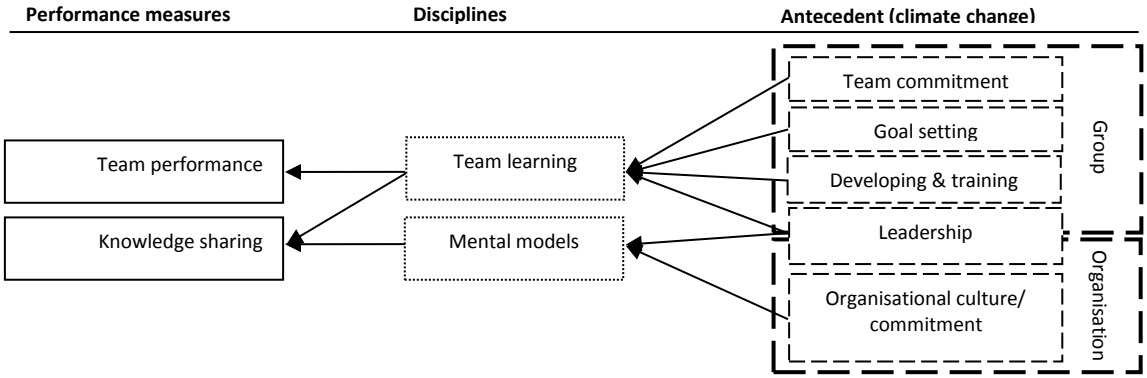


Figure 6-3: Disciplines and antecedents that facilitate 'knowledge transformation'
Source: adopted from Bui and Baruch (2010)

Step 3: Knowledge utilization

At the third step, created and shared knowledge is utilized to improve operational routines and to support strategic level decisions. Shared knowledge as part of first generation knowledge management refers to the objective to know *how* existing routines can be improved and is utilized to support day-to-day tasks as part of lower level learning. Created and shared knowledge (second generation knowledge management) is used to know *why* particular procedures are in place. It is utilized to challenge the current ways of doing things, i.e. how to redesign organisational structures and processes to increase a company's performance. As part of a *higher level learning organisation*, knowledge utilization has long term consequences on strategic market positioning and determines how to respond to environmental changes understood to be caused by climate change. In this step, adaptation strategies as part of risk mitigation in the SCRM process are shaped and finally decided. For that reason, *wise* managers should turn a knowledgeable organisation into a successful adaptive organisation by utilizing the gained knowledge to enforce the right strategic and long term impact decisions. As shown in Figure 6-4, evidence for knowledge utilization can be provided by the LO outcome factors *strategic planning* and *organizational planning* that are shaped through five antecedents.

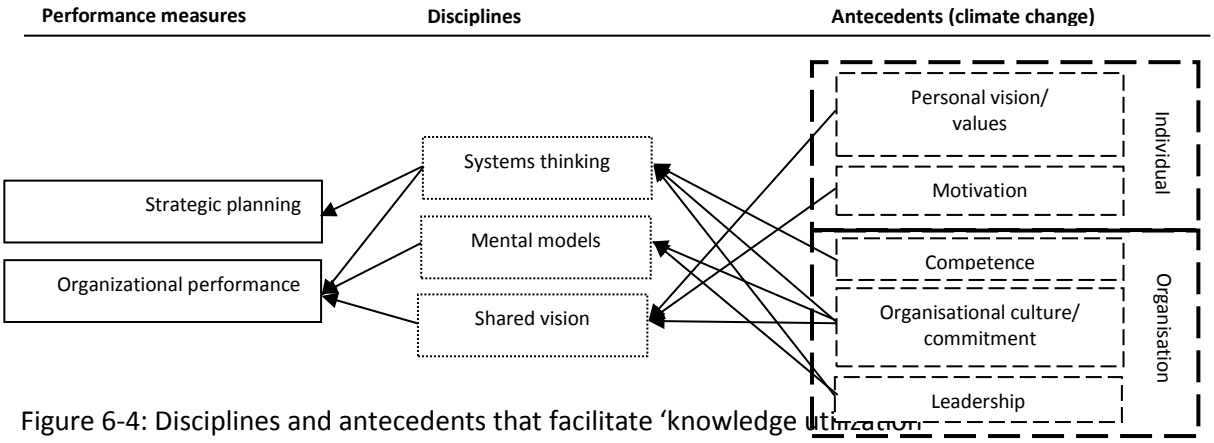


Figure 6-4: Disciplines and antecedents that facilitate 'knowledge utilization'
Source: adapted from Bui and Baruch (2010)

Step 4: Adaptation to a changing environment

The final step of the organisational learning cycle involves the actual implementation of the previously decided SC adaptation activities in response to the identified supply chain climate risk. In particular, previously made strategic decisions may result in the overall redesign of organisational structures and processes, but also in the firm's improvement of operational routines and continuity planning.

In summary, the developed *a priori* conceptual model offers a reasonable structure to may build evidence about how organisations learn about climate change. This research takes the view that in order to fully understand the impacts of climate change and decide on appropriate adaptation strategies, organisations need to complete each step in the OLC. However, supply chain climate risk is a complex phenomenon that may not impact all organisations in a supply network in the same way. Therefore, the four step organisational learning cycle might be difficult to be completed by all agents within a supply network. Also, as learning comprises understanding of climate change and adaptation to the resulting impacts, companies might be strong in one part of the OLC, but might have weaknesses in other parts of the process. Based on this assumption, the following proposition 1 (P1) was developed:

P1*: Individual organisations in a supply network do not learn about climate change, i.e. they do not understand and adapt to climate risk.*

The proposition can be verified when evidence is found that organisations do not or only partially carry out the learning cycle, i.e. companies do not pass through all four steps. Even if organisations understand climate change (i.e. steps 1 and 2), they have not learned yet as the utilization and adaptation parts of the learning cycle (steps 3 and 4) remain disregarded. In this

exemplified case, organisations would only be engaged in certain elements of the learning process, but would not learn about climate change according to the definition of learning in the thesis. Therefore, it can reasonably be concluded that not all organisations in a supply network are able to learn and eventually adapt to climate change, which consequently will also not adapt supply networks to supply chain climate risk.

6.2.2 A priori conceptual model for inter-organisational learning

Assuming that organisations are unable to learn about climate risk, inter-organisational learning is proposed as solution to facilitate adaptation of a supply network to climate change. In order to learn, organisations need to exchange created knowledge of localised impacts and develop mutually aligned adaptation strategies. It is reasonable to conclude that the developed learning cycle for organisations can also be deployed to the inter-organisational level and also passes through the four learning steps 'knowledge absorption', 'knowledge transformation', 'knowledge utilization', and 'adaptation'. It is assumed that inter-organisational learning can enable organisations to complete their learning cycles by ingesting learning strengths form other SN agents. Each organisation might contribute abilities in one or more learning steps to the community and benefits from other agents that are strong in the remaining steps. In order to create an overall learning effect, information and knowledge from each step need to be made accessible for every member to complete the learning cycle at the inter-organisational level. With reference to the concept of inter-organisational learning, it can be assumed that for-profit organisations are only willing to collaborate if they see a beneficial learning outcome of inter-organisational projects for their own company. Otherwise they might exclude themselves from inter-organisational learning activities.

Based on the literature review on inter-organisational learning and complex adaptive supply network (CASN), an *a priori* conceptual model was developed as illustrated in Figure 6-5. The model deploys the four step learning cycle to a CASN level which influences the learning process through internal mechanisms and the co-evolution with the environment.

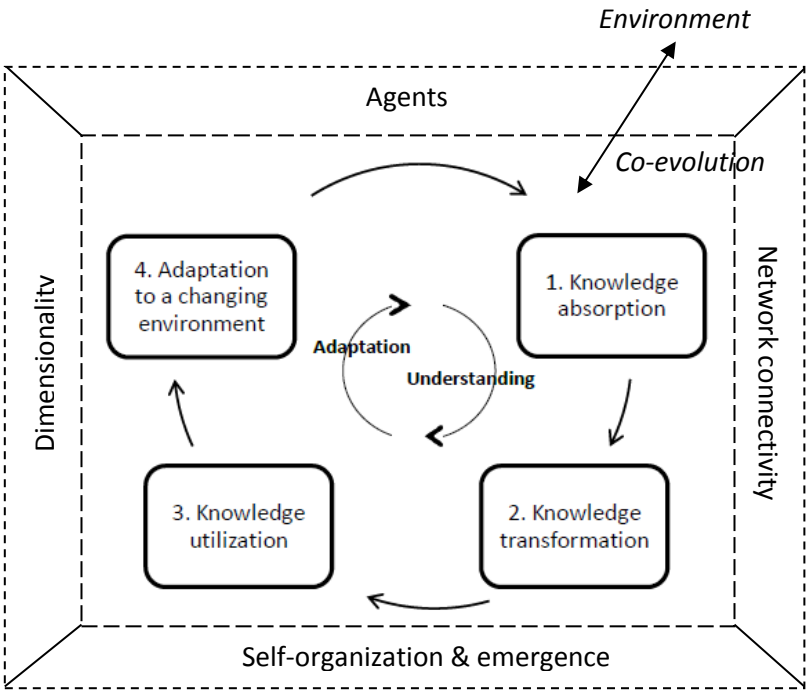


Figure 6-5: Inter-organisational learning in a CASN

With a particular focus on the internal mechanisms of a CASN (Choi et al. 2001), *agents*, *dimensionality*, *network connectivity*, and *self-organisation/emergence* manipulate the learning cycle on climate change. It can therefore be argued that the inter-organisational abilities to learn about climate change are dependent on the design and management of the four introduced factors:

- *Agents* in this research are defined as every organisation or individual that is part of the investigated supply network. As the agents' values, rules, and business strategies form the network's learning capabilities (Choi *et al.* 2001), the level of alignment must be investigated. Considering Lee's (2004) triple A-supply chain approach, inter-organisational learning relating to climate change is likely to improve if the agent's beliefs and strategies are closely aligned. It can however reasonably be concluded that the type and strength of competition impacts the willingness to cooperate. The level of rivalry amongst the agents is therefore assumed to be a critical factor for the success of inter-organisational learning as agents are unlikely to cooperate for the benefit of their competitors.
- *Network connectivity* refers to the inter-relationships between the involved organisations and to the complexity of the investigated supply network. The number of links within the network and the number of external links to the environment may therefore manipulate the learning process. As climate change impacts a supply

network globally, a high number of external links to the environment is projected which increases the dynamics of the network and the learning process. The number of internal links may vary depending on the type of inter-organisational learning. In the case of seeking for organisational benefits, companies are likely to collaborate with fewer partners. In the case of network learning for the benefit of the system, the number of internal links is likely to increase significantly, and so does the level of complexity. Besides the number of links, inter-organisational learning can also be described by the concepts of horizontal and vertical knowledge creation (Pena 2002), i.e. whether learning about climate change takes place between organisations with the same function or between different tiers. For the investigated supply network it can be assumed that vertical co-operation happens as part of the network learning process in which organisations from different tiers learn together. Horizontal collaboration and knowledge creations is expected to happen at selected tier levels that need to implement the adaptation measures and benchmark their practices.

- Dimensionality describes the degree of freedom of each agent in the supply network whereas the optimal 'edge of chaos' is the trade-off between the required level of autonomy of the agents and the need for overall rules to maintain the manageability of a SN (Choi *et al.* 2001; Tilebein 2006). The field research therefore needs to identify the optimal depth of collaboration between the organisations to enable mutual learning about climate change. Too close relationships may reduce the diversity of ideas whereas loose links may not sufficiently facilitate learning at the inter-organisational level (Desai 2010). In particular, also uncertainty about climate change (Pena 2002) as well as the understanding of SC adaptation to climate change as competitive or pre-competitive may influence the agent's chosen form of collaboration. This decision may then also have an effect on the level of shared tacit and explicit knowledge (Stonehouse and Pemberton 1994, Holmqvist 1999, and Pena 2002). Dimensionality is identified as one of the key factors that influences the learning process. It is assumed that relatively strong leadership as well as a pre-competitive environment are needed to attract and co-ordinate for-profit organisation in the network learning process that otherwise would not become part of the learning community.
- *Self-organisation/emergence* refers to the generation of new network structures and patterns without being externally imposed. Such emergent changes are typically bottom-up induced. As climate change is an external input factor on the learning cycle,

self-organisation/emergence may not be a major factor in inter-organisational learning about supply chain climate risk (SCCR).

Based on the presented a priori framework for inter-organisational learning, it can be argued that the impacts of climate change on the supply network might be understood in detail and sufficient capabilities and resources to develop adaptation strategies can be provided. Based on the suggestion that every step in the learning cycle about climate change can only be completed at the inter-organisational network level, the following proposition two (P2) is therefore developed:

P2: Networks do learn and adapt to climate change.

In order to structure the research, the developed *a priori* conceptual model on inter-organisational learning enables the researcher to reveal the influencing factors in a supply network on the learning cycle. In particular, the four introduced internal mechanisms of a CASN (agents, dimensionality, network connectivity, and self-organisation/emergence) affect the learning cycle at the network level. Their design is therefore crucial as it either fosters or hinders learning throughout a supply network. Unlike in the investigation of the organisational learning cycle, the approach for the inter-organisational level does not use output factors and antecedents to prove learning. Instead, information from the interviews about the agent's role in inter-organisational learning is triangulated with secondary data from the related project reports and websites to reveal evidence of their distinct contribution to network learning respectively.

In summary, the two introduced propositions help the researcher to answer RQ1 by identifying the type of learning that enables organisations and the supply network to adapt to climate change. Concrete examples for organisational and inter-organisational network learning that may be found from the investigated supply network allow the researcher to conclude on the first research objective, i.e. on the current learning processes about climate change throughout the supply network.

6.3 Research objective 2

Based on the findings from the first research objective, the second research objective *aims to develop a process model of supply network learning applicable to climate change risk (RO2).* In order to structure the second research objective, two more research questions have emerged. Research question two addresses the development of a network learning process to enable

adaptation to climate change. Remembering that the implementation of adaptation measures is part of the learning process according to the definition in this thesis, it can be argued that a network learning process needs to integrate learning from the organisational as well as inter-organisational level. Organisations as a result of their learning process are the entities that must implement the adaptation measures. Inter-organisational learning may help the organisations to complete their learning cycles. However, large and complex supply networks may have difficulties to initiate sector wide inter-organisational learning due to the varying organisational interests and therefore require the concept of network learning to enable adaptation. As part of network learning, organisations learn as a group in order to make the network as a whole more resilient to climate change and do not primarily focus on immediate benefits for the own company. Whereas the outcome of network learning may include changes in cognitive and mental models, this thesis defines adaptation as outcome of learning. Therefore, a network-centred view is taken that aims to reveal what parts of the network learning process happen at the organisational and inter-organisational level, respectively, in order to develop sector-wide adaptation concepts and to facilitate the actual implementation of adaptation measures. As a result, the following research question has been developed:

RQ2*:* What is the network learning process?

Given the proposed process model for network learning, it can reasonably be argued that all learning underlies particular enablers and mechanisms that facilitate or hinder organisational, inter-organisational and network learning and eventually adaptation of the network to climate change. This research is particularly interested in the enabling principles and mechanisms that facilitate network learning, i.e. what kind of network management (Knight and Harland 2005) is required to create an environment for a group to learn as a whole. The third research question is therefore developed as follows:

RQ3*:* What are the enabling principles and mechanisms that facilitate the network learning process?

Distinguishing between enablers and mechanisms, enablers are referred to as general and overall principles and concepts that facilitate the network learning process in any different kind of supply networks. In turn, mechanisms can be described as tools and practical actions that implement the general enablers and that are specific to a particular supply network. Mechanisms in this context may comprise a) strategies, i.e. long term and concrete plans to

adapt the supply network in a collaborative manner; b) structures, i.e. the determination of organisational, inter-organisational, and network structures that facilitate adaptation (e.g. flat, hierarchy, centralised, de-centralised, etc…); and c) processes, i.e. the concrete design of reporting and decision-making processes that include the flow of information, knowledge, money, and other resources within and between organisations.

In summary, the findings from the three research questions that are related to research objective 1 and 2, respectively, allow the researcher to conclude on the overall research aim to reveal how supply networks can adapt to climate change and its related risk factors. Based on the findings from the empirical research, the present learning processes at the organisational and inter-organisational level can be identified and integrated into a process model for network learning. The newly developed framework for network learning can then contribute to theory and preferably extends the existing literature in learning. Taking a more practitioner perspective, the modelled network learning process underlies distinct enablers and mechanisms that facilitate or hinder the application throughout the network. This research aims to identify the general principles to facilitate network learning (enablers) and how they can be implemented within the investigated supply network to make a particular industry adaptable to climate change (mechanisms).

Chapter 7: Research methodology

7.1 Introduction

This chapter introduces the chosen philosophical stance for this thesis and presents the research approach as well as the selected methodology. As a result, the design for the field research is discussed. This process involves selecting an appropriate case for the primary data collection as well as planning the structure of the subsequent analysis.

7.2 Theoretical perspective

This research is in the area of supply chain management and hence within the social sciences. Like all research it is shaped by the researcher's and discipline's fundamental beliefs of how to view the world (Bryman and Bell 2007). Accordingly, a number of factors impact on the research design and must be considered by the investigator to fully understand the scientific process. Figure 7-1 illustrates how the theoretical perspectives influence the inquirer's choice of methodologies and methods to conduct the research project. The theoretical base is determined by the ontological and epistemological assumptions about the nature of reality and knowledge. Both, ontology and epistemology underpin the philosophical stance of this thesis, i.e. how the researcher views reality and how to communicate this knowledge about the worldview. A range of methodologies can be used to address a chosen research paradigm, each comprising a set of data collection and analysis techniques.

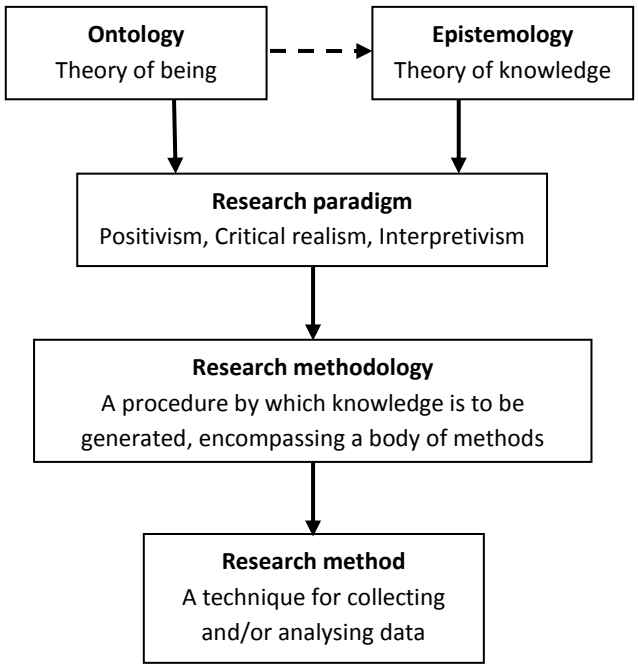


Figure 7-1: The relationship between the philosophical theory and research practice
Source: synthesised from Arlbjorn *et al.* (2008); Denzin and Lincoln (1994); Piecyk (2010); Solem (2003); and Crotty (1998)

7.2.1 Research philosophy

According to Solem (2003), our ability to solve logistics and SCM problems depends on our philosophies, worldviews, and attitudes. The philosophical position reflected in the underlying research assumptions about a particular inquiry can be described through the two main concepts from the 'Theory of Science': *ontology* and *epistemology*. Although both concepts are independent, they are related closely to each other. Solem (2003) argues that ontology implies epistemology as *"the way we are thinking about reality has a decisive influence on the way we are learning about it"* (p. 439). Each construct can be described as follows:

- **Ontology** deals with the nature of reality and describes the researcher's picture of the world, i.e. the fundamental assumptions about reality and whether reality is objective (Guba 1990). According to Solem (2003) ontology can take two opposing forms: *realism* implying that reality is external to the researcher and is of an objective nature; and *nominalism* that views reality as a product of subjectivity and individual consciousness. Easterby-Smith *et al.* (2008) additionally refer to the form of *relativism* that bridges between both extremes and argue that reality is determined through consensus between different viewpoints.
- **Epistemology** refers to the understanding of the world and how we communicate this as knowledge to others, i.e. the process of learning about the reality (Burrel and Morgan 1979). According to Morgan and Smircich (1980), the two opposing extremes of epistemology are *positivism*, i.e. knowledge is real and capable of being transmitted in a tangible form; and *constructivism,* i.e. knowledge is soft and based on experience and on a personal nature. Denzin and Lincoln (1994) argue that constructivism is synonymous with interpretivism.

The next section discusses how the combinations of the different ontological and epistemological positions create the two main research paradigms *positivism* and *interpretivism* as well as the in-between paradigm *critical realism*.

7.2.2 Research paradigm

The term paradigm has originally been developed by Kuhn (1962) and has since then attracted much research to compile a mutual understanding from different viewpoints (Arlbjorn *et al.* 2008; Masterman 1970). Collies and Hussey (2009, p. 55) define research paradigm as "a framework that guides how research should be conducted, based on people's philosophies and their assumptions about the world and the nature of knowledge". Today, two main research paradigms, *positivism* and *interpretivism,* and a number of complementary research paradigms exist, whereas each paradigm is shaped by the three elements epistemology, ontology and

methodology (Denzin and Lincoln 1994). Accordingly, a paradigm contains the ontological and epistemological position of how to view the nature of research and determines the adequate set of methods that enable the investigator to conduct the research. Emerging from the natural science that has focused on research in the physical world, the positivist paradigm has dominated research for hundreds of years. In order to properly address the rising importance of human activity in research, the interpretivism paradigm has been developed as an alternative to the positivist viewpoint (Denzin and Lincoln 1994). Table 7-1 summarises different notations for the two main paradigms that are often found and used synonymously in literature although they slightly differ in their definitions. The following sections discuss both paradigms as well as the critical realism approach that bridges the two main ones.

Positivism *A philosophical system recognizing only that which can be scientifically verified or which is capable of logical or mathematical proof, and therefore rejecting metaphysics and theism.**	**Interpretivism** *A philosophical system that views reality as non objective, but socially constructed. The world is relativistic as individual patterns shape the world view.**
Quantitative	Qualitative
Objective	Subjective
Science[7]	Humanism[8]
Traditionalist[9]	Phenomenological[10]
Natural sciences	Social sciences
Realism	Idealism

Table 7-1: Different attributes for the two main research paradigms
Source: synthesized from Naslund (2002); Denzin and Lincoln (1994); Collies and Hussey (2009)

7.2.2.1 Positivism

Positivism is underpinned by the belief that an objective reality exists. Mentzer and Kahn (1995) point out that positivism views reality as tangible, and that the positivist tradition is

[7] *The intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment.**
[8] *A rationalist outlook or system of thought attaching prime importance to human rather than divine or supernatural matters.**
[9] *The upholding or maintenance of tradition, especially so as to resist change. Chiefly historical the theory that all moral and religious truth comes from divine revelation passed on by tradition, human reason being incapable of attaining it.**
[10] *The science of phenomena as distinct from that of the nature of being. An approach that concentrates on the study of consciousness and the objects of direct experience.**
* quotations from The Oxford Dictionary

considered as *"value-free, time-free, and context independent, with the general agreement that causal relationships can be discovered"* (p. 232). Collis and Hussey (2009) summarise that *"under positivism, theories provide the basis of explanation [...]. Explanation consists of establishing causal relationships between the variables by establishing causal laws and linking them to deductive or integrated theory. Thus, social and natural worlds are both regarded as being bound by certain fixed laws of sequence of cause and effect"* (p. 56). Given this understanding of positivism, Naslund (2002) argues that phenomena under the positivist paradigm can be studied with methodologies that support quantitative methods in order to measure, analyse and generalise causal relationships statistically. One key tenet of positivism is that the social world exists externally and that phenomena should be measured through objective methodologies that do not interfere subjectively through sensation, reflection, and intuition (Easterby-Smith *et al.* 2008). The positivist paradigm has been criticised for a number of reasons. Naslund (2002) highlights six difficulties with the research under the positivist paradigm:

- *Difficulties in understanding and interpreting the methods and data:* The statistical analysis could be misinterpreted or result in false conclusions due to incomplete data or different meaning of the variables.
- *Past and not future orientated research:* Positivist research is often past-orientated and emphasises on testing existing theories. In the context of human activity, collected data from the past represents only a particular moment in time, i.e. it is snapshot only.
- *No interest for practitioners:* The benefits for practitioners are relatively small as the complex real world is oversimplified, particularly when it comes to organisational research.
- *Cultural differences:* Global research is significantly influenced by US research, that seems to dominantly apply the positivist paradigm (see also Samuel 1997).
- *Biased by tradition and publishing rules*: Academics belief to easier publish articles that are based on the positivist position and follow the established path.
- *Lack of academic vision and development***:** If every research is under the same paradigm, the discipline lacks of novel approaches, fresh perspectives and navigates itself into a narrow and isolated research area.

The argument is supported that the positivist paradigm tends to use statistical analyses to preferably generalize quantitative data. Positivism often disregards the human element and is ineligible to reveal the interpreting thoughts of humans that lay beyond obtained data. For

that reason, positivism is viewed unsuitable for research that particularly focuses on human interaction in the areas of knowledge management and (inter)-organisational learning. Indeed, much of Naslund's (2002) general criticism of the positivist paradigm can also be disagreed. For example, the dominant positivist paradigm has always attracted practitioners and the publishing process depends on the quality of the paper and the rules of the journal. Therefore, a simplistic distinction between positivism and interpretivism in the chances to publish a paper seems to be an inadequate argument to support either of the paradigms.

7.2.2.2 Interpretivism

The concept of interpretivism (also referred to as social constructivism) has been developed by philosophers in response to criticism of the positivist paradigm as outlined before. As positivism provides concepts and methodologies from natural sciences that are perceived inadequate to the needs of social scientists, interpretivism aims to address the demand for a new research paradigm (Collis and Hussey 2009). The central argument of interpretivism is the view that *"reality is not objective and exterior, but is socially constructed and given meaning by people"* (Easterby-Smith *et al.* 2008, p. 58). In particular, individuals make their own sense of the world and share their perceptions and experiences through language and interaction. As interpretivists reject the concept of viewing reality objectively, Naslund (2002) argues that the world is relativistic, i.e. the researcher needs to take the position of the individual in order to be able to understand how he or she views the world. As a consequence, the methodologies and methods contrast with those used under the positivist paradigm. Therefore, research under the interpretivist paradigm often focuses on methods that gather rich, qualitative data from which theories can be induced. Statistical generalisation, particularly from quantitative data, but also from qualitative data is less relevant to the interpretivist paradigm. Critiques of this paradigm argue that interpretivists seek for understanding of particular cases and do not aim to reveal what caused them (Easterby-Smith *et al.* 2008). Moreover, the investigator can never achieve a complete understanding of the case as the investigated interests and viewpoints shift and change over time. And so does the interpretation of the findings which weakens the reliability of the research (Vrasidas 2001).

7.2.2.3 Critical realism

The critical realism paradigm (CR) is often linked to the research by Bhaskar (1998) who takes the position that the concept of CR includes social structures which are dependent upon consciousness. He further argues that social practices always have conceptual aspects as well as a material dimension. The idea of critical realism is that in social sciences the conceptual approach and the empirical approach do not jointly exhaust the real world. Accordingly, critical realism bridges between the opposite positions *positivism* and *interpretivism* as it represents

an ontological realism, an epistemological relativism, and a judgemental rationality (Aastrup and Halldorsson 2008). CR refers to the existence of reality while simultaneously arguing for the relativity of our knowledge that always depends on theoretical constructs. In this context, Lyubimov (2011) states that *"critical realists believe that there are unobservable events which cause the observable ones; as such, the social world can be understood only if people understand the structures that generate such unobservable events".* Bhaskar (2008) argues that critical realism contains three different, but inter-related domains:

- **Real domain** contains the fundamental constructs, theories, and mechanisms that exist independently from their activation and independently from the researcher. Aastrup and Halldorsson (2008) argue that the real domain consists of underlying objects, structures, and mechanisms (unobservable events) that when activated generate events.
- **Actual domain** is the domain in which actual events occur that have been generated by the mechanisms from the real domain.
- **Empirical domain** is a domain in which the researcher observes and experiences the created events.

A key argument for critical realism is that the understanding of reality in which the actually created events can empirically be experienced is insufficient as it does not explore and explain the underlying theory and constructs that led to these events. Accordingly, the explorative analysis about the underlying and fundamental mechanisms in the real domain that create events in the actual domain is crucial to the critical realism paradigm. Viewing social systems as always open and usually complex and messy (Sayer 2000), critical realism takes the position that causal analyses should not only be based upon natural laws, but also on theories from social sciences. Aastrup and Halldorsson (2008) argue that the system's structures are partially caused by social aspects, i.e. the social structure and the material structure in a system are not necessarily congruent as usually assumed under the positivist paradigm. Benton and Craib (2001) point out that the research process under the critical realism paradigm borrows elements from the positivist as well as from the interpretivist positions. Similarly to positivism, CR seeks for objectivity in the research process. Indeed, critical realism accepts that neutrality is not fully achievable as the researcher's values and beliefs could possibly bias the findings. For that reason, critical realism supports the application of triangulation, i.e. using different quantitative and qualitative methods in order to achieve objectivity and validity as discussed in section 7.5.7.

In conclusion, each of the three introduced research paradigms makes ontological and epistemological assumptions as summarised in Table 7-2. The next section discusses the chosen research paradigm for this thesis and introduces the inductive research process to properly address the underlying philosophical stance of the research.

	Ontology	**Epistemology**
Positivism	Reality is external to the researcher and is driven by natural laws that are time- and context-free. Therefore, there is only one reality.	Knowledge is real and aims to obey a tangible form. Researchers believe that only phenomena that are observable and measurable can be validly regarded as knowledge. The inquirer aims to avoid bias of the outcomes by taking an objective, non-interactive position.
Interpretivism	Reality is a product of multiple mental constructions and individual consciousness. Reality is relative as each individual has her/his own reality, i.e. there are multiple realities.	Knowledge is soft and based on individual insights and mental models. The investigator aims to minimise the distance between the researcher and that which is researched. The inquirer takes an interactive role and a subjective perspective.
Critical realism	Reality underlies natural laws that can never be fully understood.	Objectivity remains a key goal, but cannot be fully achieved as knowledge is context dependent on human activity and social interactions. The researcher is not actively involved with that which is being investigated.

Table 7-2: Research paradigms and their respective ontological and epistemological assumption
Source: Synthesized from Collis and Hussey (2009); Solem (2003); Piecyk (2010); and Guba (1990)

7.2.3 Paradigm selected for the thesis

Various authors (Ellram 1996; Solem 2003; Kovacs and Spens 2005; Aastrup and Halldorsson 2008) argue that research in logistics and supply chain management so far seemed to favour the positivist research paradigm. Mentzer and Kahn (1995) reviewed all publications in the *Journal of Business Logistics* (JBL) between 1978 and 1993 and concluded that approximately three quarters of the methods used in the articles refer to a positivist paradigm. Being heavily influenced from the physical sciences, logistics and SCM research makes use of predominantly quantitative approaches to investigate objects of study that are related to *"tangible artefacts, but to a smaller extent [to] human intervention and influence"* (Aastrup and Halldorsson 2008, p. 3). Indeed, this philosophical stance has recently been criticised for its aim of generalisability that might not represent the real world and that does not address the businesses' needs for practical constructs (Solem 2003, Golicic *et al.* 2005). As a consequence, a number of authors

(Ellram 1996; Naslund 2002; Solem 2003; Kovacs and Spens 2005) have begun to argue over the last few years for more elements from the interpretivist paradigm to be included in logistics and SCM research. For example, Gammelgaard (2003) concluded from her review on logistics paradigms, that this discipline lacks of what she calls 'actors approach', i.e. research about the people and their interaction, about the inside of a process, and about contextual knowledge. Also Aastrup and Halldorsson (2008) argue that research under the positivism paradigm takes on the perception that logistics and supply chain management refer to a sequence of inter-related activities and structures from the raw material supplier to the end customer. In this context, normative research, i.e. research that is related to a norm and rule, is favoured to investigate cause and effect relationships between the different stages along the supply chain. They further conclude that research often investigates the impact of logistics activities on the performance level (e.g. inventory turnover, truck loads, and out of stock situations) implying that a re-design of activities and re-engineering of structures could result in better performances. As such, researchers adopting the positivist paradigm take the position that supply chains can be re-modelled from a holistic and objective perspective and assume that all involved agents, i.e. individuals, organisations, and all other stakeholders follow that new logic without questioning it. Accordingly, individuals do not have their own opinions, characteristics, and interests, but support and realise the objectives of the total system, i.e. the supply chain.

In recognition of the criticism of the traditional positivist position, this thesis applies the critical realism paradigm that bridges between the positivist and interpretivist position as discussed in the previous sections. From the positivist stance, the need for an objective, non-interactive research position is accepted to avoid bias and influences through interferences by the investigator. Also, natural phenomena as part of the environment, such as climate change for example, are underpinned by physical laws that describe cause and effect relationships. Referring to the elements of interpretivism, it can be argued for a philosophical position that views reality from a social perspective, i.e. reality exists in multiple forms of mental models that individuals have developed. The different agents' subjective positions are time and place specific and impact on the organisation's structure, processes and performance. As a result, each individual and organisation develops its own perceptions towards climate change as it is differently affected. Aastrup and Halldorsson (2008) support this argument by mentioning that the organisational activities change, as agents, learn and change their positions in open systems. Addressing the critique of the mentioned interpretivist attributes, this research investigates multiple agents within a supply network to identify more general patterns rather than subjective single opinions. In summary, it is reasonable to adopt the critical realism

position because the research on climate change rather takes the positivist approach whereas the investigation on the resulting organisational and network activities require elements from the interpretivist viewpoint.

7.2.4 Research approaches in theory

It is well established in the literature that a research process can follow the principles of a deductive or an inductive approach (Johnson 1996, Hyde 2000, Taylor *et al.* 2002). Kovacs and Spens (2005, p. 132) describe 'deductive' as *"following a direction from a general law to a specific case"*, and 'inductive' as *"moving from a specific case or collection of observations to general law, i.e. from facts to theory".* In other words, deduction draws conclusion from literature in the form of hypotheses and propositions to be then tested through empirical research. Then, the corroboration or falsification of the hypotheses enables researchers to present general conclusions. Positivism is strongly linked to a deductive research approach that focuses on testing theories. Yet, Arlbjorn and Halldorsson (2002) demand more inductive approaches in SCM and logistics research to develop new theory. Inductive research follows an opposite direction and begins with observations of the world and concludes from the findings on theory that can then later be generalized by empirical research. Pre-existing knowledge in the form of *a priori* frameworks about existing theory can be held, but is not necessary for inductive research.

Bridging the deductive and inductive approach, recently the "abductive" approach has been developed in social sciences (Danermark 2001). The abductive reasoning process enables the researcher to *"move back and forth between events and possible causal powers, in order to justify possible explanations and eliminating alternative explanations"* (Aastrup and Hallsdorsson 2008, P. 757). Accordingly, abductive research aims to *"determine which aspects of a situation are generalisable and which others only pertain to the specific situation itself, stemming, for example, from situational environmental factors"* (Kovacs and Spens 2005, p. 138). To do so, the researcher is able to distinguish between the general and the particular features of a determined case (Danermark 2001).

Kovacs and Spens (2005) summarise the three research approaches as follows:

- **Deductive**: *from rule to case to result (RCR)*; i.e. a developed theory in the form of hypothesis is tested under a particular case and as a result proven true or false.
- **Inductive**: *from case to result to rule (CRR)*: i.e. one or multiple cases provide data to be analysed on various results that can then be aggregated to general rules.

- **Abductive**: *from rule to result to case (RRC):* i.e. a rule is analysed on its practical relevance; from these results, conclusions can be drawn on general elements of the rule, and newly required specific elements under a particular case to which the (adjusted) rule is applied.

7.2.5 The inductive research approach for the thesis

The overall research approach for this thesis is inductive, even though it contains some deductive elements. The inductive approach is reasonably selected as the research does not aim to test already developed theory on 'supply chain adaptation to climate change' for generalization as under the deductive approach, but rather aims to newly identify the underlying mechanisms and patterns in the area of (inter)-organisational learning that enable adaptation of supply networks to climate change. Even though inductive as well some deductive elements are applied to this research, the abductive approach is also inappropriate. The developed learning cycle is not empirically tested under real cases to be then modified, but is used as a structured framework to reveal new theories about the mechanisms that enable the adaptation of supply networks to climate change. Following the case-result-rule-logic under the inductive approach, the research process addresses a particular domain under the critical realism paradigm as summarised in Table 7-3. First, the aim is to collect empirical information from a particular supply network to be analysed. For that purpose two developed models on organisational and inter-organisational learning structure the analysis. Even though no hypotheses are statistically rejected or verified, the first phase has a deductive element as existing rules in the form of propositions are tested under a particular case. Then, information gained from the field research is used to reveal the learning processes at the organisational and inter-organisational levels of the investigated supply network. Finally, conclusions can be drawn on the required learning processes to enable the adaptation of supply networks and the underlying enabling principles and mechanisms that facilitate the proposed learning process. The determined learning process (rule) might then be later tested in a deductive research approach for generalisation.

Research logic	**The inductive research process in this thesis under the CR paradigm**
Case	Initially, a particular case is selected to collect data from, i.e. the developed *a priori* frameworks for organisational and inter-organisational learning are investigated under the selected case. Deductive elements are part of this first phase as data is collected according to the structure of the *a priori* frameworks. The researcher aims to collect data from the 'empirical' domain in the critical realism paradigm.

Result	Derived from the received data from the 'empirical' domain, conclusions can be drawn on the 'actual' domain, i.e. a picture can be drawn of the learning processes at the organisational and inter-organisational level of the investigated case.
Rule	Concluding on RO1 and RO2, the required learning process for network adaptation can be determined and modelled. Also, the underlying enabling principles that facilitate the concluded learning process can be identified ('real domain'). Both findings then might be tested for generalisation in subsequent research.

Table 7-3: The inductive research logic in this thesis

7.3 Research framework

According to Yin (2009), the objective of the research process is to provide a logical plan from the initial research idea to the reasonable conclusions. McGrath (1982) states that the research process is *"a series of logically ordered...choices. Those choices run from formulation of the problem, through design and execution of a study, through analysis of results and their interpretation. The series of choices is locally directional: plan must come before execution; data collection must come before data analysis"* (p. 231). Following this logic, various authors (Collies and Hussey 2009, Easterby-Smith *et al.* 2008) have discussed the general outline of a generic research process that is applicable to any research project in any discipline. Such research process typically includes the following steps:

1. Formulation of the problem
2. Development of hypotheses and research questions
3. Planning the study
4. Data collection
5. Analysis and interpretation
6. Presentation of results

Mentzer and Kahn (1995) took on this generic process and developed a distinct research framework that aims to serve researchers in the area of logistics, but that can also be used for SCM research. The process consists of three key parts and can be described as follows:

Part A: Idea generation to substantive justification

Heriot-Watt University is well known for its research focus on 'Green Logistics' to address the generated public interest in the causes for climate change and the resulting impacts on humans and businesses. However, much of the current research at Heriot-Watt and to be found in literature relates to the question of how to mitigate the effects of global warming, i.e. how to cut carbon emissions, for example. As climate change is already happening (IPCC 2007c), organisations begin to realise that climate change has increasingly been causing

difficulties along the supply chain and consequently impacting negatively on the firm's performance (Macbeth *et al.* 2009). In conclusion, an opportunity for new research on adaptation to climate change was reasonably identified. Even though many initiatives are set up the public sector and refer to transportation issues (e.g. Adaptation Scotland 2013, GTZ 2012, Highway Agency 2011, TRB 2008, Chapman 2007), few attempts have been made to investigate supply chain adaptation to climate change in the private sector. Based on this information, the relevant literature was intensively reviewed in order to support the evolution from the initial research idea into substantive justification of the developed research questions and propositions.

Part B: Theory constructs to methodology

After establishing the substantive justification of the research, two *a priori* constructs on organisational and inter-organisational learning were developed from the literature review. The frameworks describe the different phases to pass through in order to understand changes in the environment and to develop appropriate adaptation strategies as part of the learning process. The *a priori* models further provide a structure to conduct the field research and to analyse the received data. On that basis, the philosophical position (critical realism), a suitable research methodology (case study), and the method (semi-structured interviews) to collect primary data are selected.

Part C: Analysis to conclusion

After all necessary data was collected during the field research, the information obtained were then analysed and conclusions on the research questions were drawn. Following the framework of the semi-structured interviews, learning at the organisational and inter-organisational level was analysed. The findings extend the literature in learning by proposing a process model for network learning, and have also a practical relevance. The thesis contributes recommendations to be implemented by decision makers to facilitate the adaptation of the supply network. The results were presented at conferences and workshop (e.g. ELA doctorate workshop 2012, etc…) and discussed with industry experts (e.g. the free-lancer Kertsin Linne, etc…) in order to get valuable feedback and comments that were then integrated into the final conclusions. As last part of this part, the generalizability and limitations of the thesis' outcome as well as the directions for future research are discussed.

7.4 Research methodologies

It is important to choose a methodology and research method that meets the chosen philosophical stance. Collis and Hussey (2009) refer to methodology as *"an approach to the process of the research, encompassing a body of methods"* whereas a method can be described as *"a technique for collecting and/or analysing data"* (p. 73). As summarised in Table 7-4, the main paradigms are associated with particular methodologies, methods and types of data.

Research paradigm	Methodology	Method	Data
Positivism	Experimental studies Survey Cross-sectional studies Longitudinal studies	Questionnaire Statistical analysis Simulation Modelling	Quantitative
Interpretivism	Ethnography Participate enquiry Action research **Case studies*** Grounded theory	**Interview*** Observation Focus group Narrative Recording & Transcription Analysing text and documents	**Qualitative***

* selected in this thesis

Table 7-4: Methodologies, methods and data associated with the main paradigms
Source: adopted from Collis and Hussey (2009); Crotty (1998); and Silverman (1993)

Methodologies such as experiments and surveys for example, and methods such as questionnaires and statistical modelling are the preferred choices to conduct research under the positivist paradigm. Taking the interpretivist position, researchers favour methodologies such as ethnography, action research and case studies, and use methods such as interviews and focus groups in order to gain in-depth knowledge of the objective of research (Collis and Hussey 2009; Easterby-Smith *et al.* 2008; Crotty 1998). Distinguishing between *quantitative* and *qualitative*, some researchers (e.g. Alvesson and Skoldberg 1994; Naslund 2002, etc…) refer to research paradigms whereas others (e.g. Collies and Hussey 2009, etc…) refer to data. Taking on the latter position and arguing that quantitative as well as qualitative data can be related to both main research paradigms, the data collected in a positivist study tend to be quantitative variables that are highly specific and precise in order to facilitate statistical analysis. As those applying the interpretivist paradigm tend not to analyse data statistically, the collected data is often in qualitative form that requires other forms of analysis.

Although under the chosen critical realism paradigm, methodologies and methods from both ends could potentially be used, the case study approach is selected as the only research methodology in this thesis as justified in the next section. By doing so, the difficulty is to get

access to valid and reliable data. From the critical realist perspective, multiple viewpoints need to be taken into consideration to conclude on the underlying theory that explains social relationships and interactions. The principle of considering different sources of evidence is referred to as triangulation. Denzin (2006) argues that triangulation aims to achieve higher validation of the research results through cross verification by using and combining as many methodologies, methods and data as possible studying the same phenomenon. Easterby-Smith *et al.* (2008) and Patton (2002) discuss four different types of triangulation:

- **Data triangulation**, where triangulation is achieved by using multiple sources of data, but corroborating the same fact or phenomenon.
- **Investigator triangulation**, where triangulation means that different investigators collect and evaluate the same fact or phenomenon independently.
- **Theory triangulation**, the same data set is investigated by perspectives and theories from different disciplines.
- **Methodological triangulation**, where research methods to collect quantitative and qualitative data from the same research paradigm are employed. This approach may lead to stronger validation of the developed theoretical constructs (Eisenhardt 1989).

Based on the decision to conduct a case study only, the design must strongly focus on enabling data triangulation from multiple agents as part of the investigated case in order to achieve a valuable research result. Even though the data collected is predominantly of qualitative nature, quantitative data might also be obtained in the form of financial figures, for example. That however does not fully represent the methodological triangulation approach. With reference to the later introduced consultant Kerstin Linne who assisted during the data collection process, investigator triangulation is also not fulfilled as she mainly advises during the interviews and contributes with her specific sector knowledge to the research. She does not conduct own research in the same area as this thesis. Finally, theory triangulation is not carried out as this research is limited to the discipline of supply chain management.

7.5 Case study

Yin (2009, p. 18) defines case study as *"an empirical inquiry that investigates a contemporary phenomenon in depth and within its real life context, especially when the boundaries between phenomenon and context are not clearly evident".* He further notes that case study inquiries reveal a high number of variables and data, rely on multiple sources of evidence, and can benefit from *a priori* constructs to streamline the data collection and analysis process. Eisenhardt (1989) notes that a case study focuses on the understanding of the dynamics present within single settings. She argues that a key strength of the case study approach is the

development of novel theory that is unbiased by perceptions and unlimited by hypotheses. Therefore, the case study is useful *"in the early stages of research on a topic or to provide freshness in perspective to an already researched topic"* (p. 548). This perception fits entirely to this thesis that aims to investigate new approaches of supply chain adaptation to present and future impacts of climate change. Addressing the prejudice that the researcher cannot generalize from case study results, this type of research aims for 'analytic' generalization, i.e. existing theory is developed further by adding new elements that are derived from empirical results. As cases are not chosen as sampling units, newly created theory from case study research does not aim for and does not enable 'statistical' generalization (Yin 2009).

The importance of the case study research methodology has been discussed by various authors in the field of logistics and supply chain management. Ellram (1996) argues that case study research is not well understood in logistics management and is therefore ranked relatively low as preferred research method. Yet, Mentzer and Flint (1997), Hilmola *et al.* (2005), and Seuring (2005) take the position that the case study approach has been a widely deployed research methodology and according to Larson and Halldorsson (2004) is ranked as high as other methodologies among researchers in the logistics discipline. Seuring (2008) concludes that in the area of supply chain management the case study research methodology has been fully developed and can be carried out in a rigorous way. Aastrup and Halldorsson's (2008, p. 747) view *"the use of case study research as an approach to scientific inquiry; for theory building and for change and business impact".* Synthesising the key arguments to use the case study methodology in SCM and logistics research from Naslund (2002), Aastrup and Halldorsson (2008), and Ellram (1996), the case study approach is selected for the following reasons in this thesis:

- The case study methodology can be epistemologically justified as, given the critical realism position, a case study offers the depth to uncover and analyse the underlying structures and causes for observed organisational events and actions. This is particularly necessary in this thesis, as (inter)-organisational learning about climate change is not well researched and therefore requires an in-depth research approach.
- Although the best way to conclude on cause and effect might be achieved through other research approaches such as experiments, for example, the case study methodology is a much more suitable research tool in the area of social sciences. Yin (2009, p. 4) highlights, that case study research contributes to the *"knowledge of individual, group, organizational, social, political, and related phenomena".* Individuals may change their behaviour and perceptions, and organisations are not closed and

fully controllable systems. Therefore, it is reasonable to conclude on the prevalence of case studies over alternative research methods to be able to investigate organisational and inter-organisational structures and processes that facilitate SN adaptation to climate change. Accordingly, the case study approach is mostly suited to investigate the three research questions as introduced in the previous chapter.

- Case studies rely not necessarily, but often on qualitative data sources such as interviews, for example. Derived from the gained immaterial elements such as reasons, opinions, perceptions, and interests, conclusions can be drawn on the causal powers that shape logistics and SCM events and practices. Accordingly, the case study methodology is justified as it enables the researcher to analyse the effects of agents' interpretations in specific contexts. There is also a strong argument to use case studies in the context of supply chain adaptation to climate change. The research focus is on (inter)-organisational learning that implies different levels of knowledge and relationships among all individuals. The research does not aim to provide normative solutions such as developing a model for optimized inventory under a positivist paradigm, for example. Therefore, this thesis disagrees with the implicit assumption under the positivist paradigm that developed solutions for identified logistical problems are fully accepted and implemented without being questioned by the agents within the supply network. Rather, the case study approach targets to reveal the causal powers and underlying mechanisms that lead to adaptive actions in response to a changing environment.
- Yin's (2009) argument is accepted that the findings from case study research cannot be statistically generalised. However, it can be argued from a critical realism position, that case study-based research has its legitimacy in the theory-enhancing explanatory role that investigates the mechanisms responsible for ascertained regularities (Tsoukas 1990). This perception is deployed in this thesis by exploring the fundamental enablers that facilitate supply networks to adapt to climate change.
- The research on supply chain adaptation to climate change is a new topic for research in business management and currently at an exploratory stage. Therefore, other research methods such as surveys, for example, would probably get poor responses.

In order to achieve a rigorous case study design and to avoid losing the focus on the most important relationships through too much data gathered and too complex constructs developed, Seuring (2008) emphasizes on the importance of adequate information and documentation about the research process. Various authors (Eisenhardt 1989; Ellram 1996;

Voss *et al.* 2002; Yin 2009) have presented similar research processes for case studies. To ensure high quality of the research, Yin (2009) proposes a six-stage process for conducting a case study. The process follows a linear and sequential approach, but allows for iteration of several stages with newly gained knowledge during the research process. Table 7-5 summarises the six stages and clarifies how the research process is applied to this thesis.

Stage	Description	Chapter/Section
Plan	- Identify research questions - Identify the nature of the research project	6.1/6.2 7.5.1
Design	- Determine the "unit of analysis" - Selection of companies to take part	7.5.2 7.5.2/7.5.3
Prepare	- Prepare interviews and develop questions - Carry out pilot case study	7.5.4/Appendix C 7.5.5
Collect	- Follow case study protocol - Create case study database	7.5.6 Digital appendixes (D to O
Analyze	- Case description - Analyses of (inter)-organisational learning - Answering RQs, theory building - Conclusion on research aim	8 9/10 11 12
Share	- Publicizing of doctoral thesis - Study report for the coffee sector	October 2013 Due to be published spring 2014

Table 7-5: Overview of case study research process

7.5.1 Nature of the research

It is well established in literature that case studies are the preferred research methodology, when 'how' and 'why' questions are being posed and when the focus is on contemporary events within the real-life context (Yin 2009; Ellram 1996; Eisenhardt 1989). In line with the critical realism paradigm, the overall research aim is a based on a 'how' questions, i.e. *'How can supply networks* adapt to climate change and its related risk factors?'. In order to systematically conclude on the overall research aim, the structure as shown in Table 7-6 has been developed.

Overall research aim	Research objective	Research question	Propositions
***RA**:* The aim is to determine how supply networks can adapt to climate change and its related risk factors			
	***RO1**:* To examine the current learning processes of organisations and networks relating to climate change risk.		
		***RQ1**:* What type of learning enables companies and networks to adapt to climate change risk?	
			***P1**:* Individual organisations in a supply network do not learn about climate change, i.e. they do not understand and adapt to climate risk.
			P2: Networks do learn and adapt to climate change.
	***RO2**:* To develop a process model of supply network learning applicable to climate change risk		
		***RQ2**:* What is the network learning process?	
		***RQ3**:* What are the enabling principles and mechanisms that facilitate the network learning process?	

Table 7-6: Overview of research aim, objectives, questions, and propositions

Depending on the research aim, a case study can follow an exploratory, descriptive, or explanatory design. Table 7-7 summarises the key characteristics of each objective and shows how they are related to this thesis. Despite some descriptive and explanatory elements, the overall nature of the case study for this thesis is exploratory. Addressing both research objectives, initially a detailed picture of the learning processes at the organisational as well as inter-organisational level within the investigated supply network is created. It describes the structures, processes, and interactions throughout the particular case, but also comprises an explanatory element to discuss the cause and effect relationships between the agents and resulting actions. Referring to the second research objective, a process model for supply network learning about climate change is designed and a number of enabling principles and mechanisms to facilitate the learning process should be revealed. Accordingly, to the author's knowledge, it is the first time that adaptation of supply networks to climate change is explored. Extending the literature on learning, the findings and conclusions from the investigated case may later be tested for generalization by another research.

Objective	Questions	Explanation	Relevance for this thesis
Descriptive	Who, what, where	This type of case study provides a full description of the nature of a phenomenon, i.e. who is performing what kind of activity and where is it done.	Initially, the learning processes of the investigated supply network are revealed. That includes a description of the current learning activities, projects, goals and inter-relationships between the interviewed and considered SN agents, respectively.
Explanatory	How, why	Explanatory research probes the how and why questions and aims to collect data on the cause – effect relationship in order to explain how events happened.	The analysis goes beyond a pure description of who is doing what. The investigation also includes the identification of cause and effect relationships, i.e. for what reason (why) are particular processes and structures in place and how do they impact the learning cycle.
Exploratory	How, why	The objective is to provide in-depth knowledge of a little known phenomenon. This type of case study aims to build theory to be tested by further studies (not necessarily case studies).	The thesis contributes to learning theory and also proposes a range of enablers and mechanisms that facilitate the learning process. A new process model for network learning is proposed based on the findings of the investigated case Overall; it is the first time that adaptation of supply networks to climate change is explored.

Table 7-7: Overview of objectives of case study research and relevance for this thesis
Source: synthesized from Yin (2009), Seuring (2008), and Ellram (1996)

7.5.2 Criteria for company selection

The accurate selection of companies to take part in the field research is essential to achieve consistent and valid research results. Eisenhardt (1989) argues that cases are chosen for theoretical or content and not for statistical reason, i.e. the selected cases usually do not represent the population. She points out that *"the goal of theoretical sampling is to choose cases which are likely to replicate or extend the emergent theory"* (p. 537). Moreover, the case study design must ensure the match between collected evidence and original research questions (Yin 2009). Therefore, this section firstly presents the reasons for selecting a single case study approach, and secondly discusses the criteria that companies within the supply network must fulfil to be regarded as potential organisation to collect data from.

Selecting the "unit of analysis"

The 'unit of analysis' is the same as the definition of 'case' and is strongly related to the research questions posed. In order to give a reasonable and robust answer to the research aim, the unit(s) of analysis, i.e. case(s), must be selected carefully and plausibly. In particular,

the researcher must decide on a single-case or multiple-case design and needs to choose between a holistic and an embedded case study. In order to make a decision for a single- or multiple-case design, Yin (2009) provides a number of arguments for one or the other as summarised in Table 7-8.

Argument for a single-case design	**Arguments for a multiple-case design**
The selected single case represents - a *critical* case, i.e., all conditions for testing a theory are likely to be met - an *extreme* or *unique* case, i.e. a case that is very rare due to its distinct characteristics - a *typical* case, the phenomenon involves day-to-day or commonplace situations - a r*evelatory* case, i.e. when the opportunity to investigate a phenomenon has previously been inaccessible - a *longitudinal* case, i.e. a single case is studied for two or more points in time	- None of the arguments for a single case study design is valid - The evidence of multiple cases is more robust than with a single case study - Multiple cases allow for literal and theoretical replication - Prior knowledge of the outcomes can be investigated with multiple cases hoping for replication or allowing for the creation of new theory

Table 7-8: Major reasons for a research design with a single case or multiples cases
Source: adapted from Yin (2009)

Transferring the distinct arguments for both research designs to this thesis the single case methodology is used. Although the single case design to investigate SC adaptation to climate change is not supported by arguments such as extreme or typical everyday phenomenon, and iterative research (longitudinal case), arguments can be found that address the revelatory case. As climate change has only recently begun to impact organisations and supply networks, an opportunity to investigate the responding actions has newly emerged. Moreover, this thesis does not solely take the company perspective, but regards an entire supply network, i.e. data from various organisations must be collected. As such, 'case' in this thesis is defined as a supply network. Therefore, a single case study can best address the complexity and the number of agents to be considered in a worldwide supply network. It allows the researcher to reach the required level of in-depth information and to investigate processes, structures and managerial behaviour in detail. Accordingly, valid and robust results can be achieved through a profound understanding of the organisational and managerial interactions within a complex system and do not necessarily require evidence through replication from multiple cases. Besides, replication of knowledge management and learning processes is supposed to be difficult in multiple (global) supply networks. Considering the inductive research approach, it is

reasonable to conclude that using multiple cases, i.e. multiple supply networks, will not result in more reliable findings as the findings developed from a single case involve already multiple agents as part of a global supply network.

Each case study can also be holistic or embedded. Holistic means that the case study investigates the global nature of a phenomenon or organisations. Embedded stands for various subunits of analysis, i.e. different programmes or organisations throughout a particular case. As a result, the selected single-case study design can involve only one company, i.e. holistic single-unit analysis or multiple organisations, i.e. embedded single case study with multiple units of analysis. The nature of a global supply network requires an embedded single case study design whereas the particular research objective is investigated throughout multiple organisations that interact with each other. As a result, conclusions can be drawn about the knowledge and learning processes of individuals, organisations, and the supply network as a whole.

Criteria for selecting a company

Based on the decision to conduct a single embedded case study, the following criteria must be considered when selecting a supply network as appropriate case to be investigated in the field research:

1. The selected supply network must consist of numerous agents that preferably have a general interest in collaborative relationships to facilitate mutual adaptation activities. Otherwise the importance of inter-organisational learning (P2) for adaptation would be difficult to investigate. The network should also have a certain level of complexity, i.e. at least three tiers.
2. The supply network should preferably be sensitive to climate change. As such, the supply network should have already been impacted by climate change and observed significant consequences that require responding actions. This criterion might best be fulfilled by a food or consumable supply chain that includes agricultural products. Such products might be impacted by the five climate risk factors as follows:
    a) *Water* is a vital component when growing natural products. Insufficient water supply and continuous change in weather patterns may result in a decline of crops as too little or too much rain and flooding reduce the quantity and quality of all different kinds of yields.
    b) The risk factor *Food* can also refer to the soil conditions which are likely to be affected by climate change. Increases in temperatures impact negatively on the current composition of fertile soils that are needed for particular

agricultural products. A change in environmental conditions may displace currently grown products and lead to monocultures as well as intense competition among various agricultural products for the remaining cultivatable areas.

c) Changes in the climate factor *ecosystems* may have only an indirect impact on the agricultural sector. Extinction or overpopulation of species may influence the quality and quantity of the soil and yield.

d) The agricultural sector is highly vulnerable to *extreme weather events*. Heavy rain (flooding), hail, frost, heat, or hurricanes could damage or destroy entire crop yields. There is no agricultural product that is not vulnerable to extreme weather events as all are directly exposed to the sometimes devastating impacts. However, some products might be more resilient to climate change than others.

e) Finally, the *risk of much more rapid climate change* is also very significant to the agricultural sector as many products require a long cultivation time before the harvesting is even possible or reaches a significant outcome. Hence, a long planning horizon in terms of financing and plantation is required for some agricultural products that might be considerably shortened if climate change will happen more rapidly.

- Considering the moderator 'size' that influences the learning process (Bui and Baruch 2010), this thesis does not refer to company size, but to the size of a supply network. As climate change causes worldwide different kinds of impacts and at varying intensity, the supply network investigated should preferably consist of globally dispersed agents.
- As the field research is not a laboratory experiment, but carried out in the real business world, substantial support from top management and employees is required to get a deep understanding of the organisational and inter-organisational processes and relationships that facilitate decisions.

Derived from these selection criteria, supply networks containing meat, cocoa, tea, soy, cotton, coffee, or fishery products may be eligible for the field research. Eventually, a coffee supply network (CSN) is selected as suitable case study object for the following reasons:

- The CSN is a complex network that consists of various organisations at different levels that add value from the farmer to the end-customer. The coffer sector provides the

context for the single case study whereas the different agents (farmers, traders, roasters, etc…) are spread across the globe.

- As the CSN belongs to the broader agricultural sector, it is already highly affected by climate change. The main vulnerability of the supply network is at the sources of raw materials that are directly exposed to the impacts of climate change, i.e. at the farm level that produces the green coffee.
- The CSN is a globally operating network. The impacts of climate change are likely to be location specific which increases the complexity of the case as coffee is grown in different countries around the world such as in Kenya, Vietnam, and Guatemala, for example.
- The coffee sector is also very open minded for research on climate change and the culture in this sector is collaborative in nature, i.e. top management support from various organisations is highly likely.

7.5.3 Overview of organisations involved in the single embedded case study

Based on the decision to collect data from a coffee supply network, the following steps were taken to get in contact with organisations in this particular sector:

a) A short advertisement that informs about the research was created and distributed by the German Coffee Association to its members as part of the 35th newsletter on 2nd July 2012 (see appendix A).

b) Kerstin Linne, who is a freelancing consultant to the coffee sector and an expert in mitigation and adaptation planning to climate change, responded per email to the advertisement on 4th July 2012. She offered to make contact with the relevant managers and organisations from the farmers' to the roasters' level. She also volunteered to assist with the interviews as she knows most interviewees well. There is no financial agreement or any other obligation as a result of Kerstin's assistance. Her motivation is to re-fresh her contacts and to update some of the interviewees on running projects about mitigation and carbon footprint calculations in the coffee business. In summary, Kerstin's role in the research can be described by the following attributes:

    - Making initial contact with potential interviewees and informing about the research. Mostly, interviewees are sent an email to which the author's designed research overview is attached. In any cases, the researcher is copied into every correspondence to monitor the progress and to actively engage

when necessary. This approach is very useful as cold calls to companies might not be very successful.

- Kerstin's expertise in the coffee business makes it easier for the researcher to understand the inter-relationships between the involved organisations and how the complex coffee supply network works. As such, the research design is already based on a general understanding of the coffee business. She assists in designing the semi-structured interview and attends every discussion with the interviewees.
- Kerstin's role is limited to providing business insights to the researcher, to initiating the contacts with possible organisation to collect data from, and to assisting during the actual interviews by clarifying specific terminology and providing background information when necessary. In this context, Kerstin also might ask some questions that refer to the semi-structure of the interview, but the researcher always takes the lead and is in control of the questioning.
- The only exception from these limitations: as one interviewed farmer only speaks Spanish and the researcher not, Kerstin conducted this interview according to the determined semi-structure.

c) Possible candidates to approach for the interviews were selected and emailed a short presentation to inform about the research (see appendix B). Preferably, interviews were organised face-to-face to also easily collect secondary data such as company leaflets and project reports (Easterby-Smith *et al.* 2008). However, for economic and time reasons, conference calls on the phone or via Skype were also arranged, particularly with participants from overseas. Organisations with different functions in the supply network, e.g. farmers, traders, roasters, NGOs, and others were contacted and interviews were scheduled between August 2012 and March 2013.

d) The aim was to hold interviews with a minimum of two different agents from each functional group in the supply network. Accordingly, at least two traders and two farmers, for example, need to provide data in order to avoid extreme opinions and to achieve a certain level of triangulation for each tier in the coffee SN. Preferably, additional sources of evidence, i.e. further interviews, but also secondary data about carried out projects, are used for each group as well.

Table 7-9 summarises the interview details including the names of the companies and interviewees, their respective positions, place and time of the interviews, and contact details.

No	Company/Person	Position in the SN	Interviewee(s)	Position in the company	Contact details	Place and time	Type of interview
1	Cafédirect (CD)/ Cafédirect Producers Foundation(CDPF)	Roaster/ Trader	Wolfgang Weinmann Claire Rhodes	Head of Impact and Sustainability at CD Managing Director at CDPF	WWeinmann@Cafédirect.co.uk CRhodes@Cafédirect.co.uk	London, UK 14th August 2012	Face-to-Face
2	UTZcertified	Standard	Laurens van Oejen Vera Espindola Rafael	Partnership Development Manager Field Development Coordinator Latin America	Laurens.vanOeijen@utzcertified.org Vera.Rafael@utzcertified.org	Amsterdam, Netherlands 4th September 2012	Skype
3	Fairtrade	Standard	Carlos Canales	Policy Manager, Climate Change and Sustainable Development	c.canales@Fairtrade.net	Bonn, Germany 7th September 2012	Face-to-Face
4	4C Coffee Association	Standard	Lars Kahnert	Funding Manager	Lars.kahnert@4c-coffeeassociation.org	Bonn, Germany 7th September 2012	Face-to-Face
5	Rainforest Alliance	Standard	Jeff Hayward	Director Climate Program	j.hayward@ra.org	Washington, USA 28th September 2012	Skype
6	Hans R. Neumann Stiftung (HRNS)	Implementer	Michael Opitz	Managing Director	Michael.Opitz@hrnstiftung.org	Hamburg, Germany 25th October 2012	Face-to-Face
7	Armajaro Trading	Trader	Jason Green	Manager Agriculture and Project-Planning	Jason.Green@Armajaro.com	London, UK 9th November 2012	Phone
8	Sustainable Management Services	Farmer	Bernard Njoroge	Project Manager	Lybern2008@yahoo.com	Kirinyaga, Kenya 15th November 2012	Skype
9	Cooperative Juan Sabines Gutiérrez in Chipas, Mexico	Farmer	Julio Alfaro Ramiréz	Consultant/Agronomist and farm owner	j-alfaroramirez@hotmail.com	Chipas, Mexico 20th November 2012	Skype
10	GIZ	Implementer	Eberhard Krain Sophie Grunze	Manager Agricultural and Forestry Sustainability Standards C&C Project Manager	Eberhard.krain@giz.de Sophie.grunze@giz.de	Eschborn, Germany 20th November 2012	Phone

11	Gollücke &Rothfos (Volcafe group)	Trader	Tom Fülles	General Manager	tfuelles@grbcoffee.com	Bremen, Germany 26th November 2012	Face-to-Face
12	Ecom Trading	Trader	David Rosenberg	Corporate Sustainability Manager	Drosenberg@ecomtrading.com	Lausanne, Switzerland 27th November 2012	Phone
13	Tchibo	Roaster	Stefan Dierks Cornel Kuhrt	Category Leader CR Product & Strategy Corporate Sustainability Senior Manager Corporate Responsibility	Stefan.dierks@tchibo.de Cornel.kuhrt@tchibo.de	Hamburg, Germany 3rd December 2012	Face-to-Face
14	Natural Resource Institute, University of Greenwich	Scientist	Jeremy Haggar	Head of Department for Health, Agriculture & Environment	J.P.Haggar@greenwich.ac.uk	London, UK 4th December 2012	Face-to-Face
15	International Centre for Tropical Agriculture (CIAT)	Scientist	Peter Läderach	Researcher International Centre for Tropical Agriculture (CIAT)	P.Laderach@cgiar.com	Kenya 16th January 2013	Skype
16	Gustav Paulig	Roaster	Leena Miettinen	Corporate Responsibility Manager	Leena.Miettinen@paulig.com	Helsinki, Finland 21st January 2013	Phone
17	Néstlé	Roaster	Duncan Pollard	Sustainability Advisor to José Lopez, the Executive Vice President of Operations at Nestlé.	Duncan.pollard@nestle.com	Vevey, Switzerland 11th March 2013	GGGPhone
18*	IDH	NGO	Jenny Kwan	Senior Program Manager Coffee	kwan@idhsustainabletrade.com	Utrecht, Netherlands 24th February 2013	Face-to-Face

*IDH is a collaborative initiative in the coffee sector and not considered as SN agent. Therefore, the interview is only used in the analysis section on inter-organisational learning.

Table 7-9: Companies and interviews conducted within the case stud

7.5.4 Preparation for semi-structured interview

The interview method is chosen to collect primary data under the case study methodology. It can be customized to each interviewee in the coffee supply network and enables the researcher to collect the required level of in-depth information. Interviews can be structured (survey-like), semi-structured (focus interview), or unstructured (in-depth interview) (Easterby-Smith *et al*. 2008; Yin 2009). Collis and Hussey (2009) argue that structured interviews tend to be used under the positivist paradigm whereas the interpretivist paradigm normally demands for unstructured interviews to deeply explore opinions, attitudes and patterns. With reference to the developed *a priori* models on learning cycles, semi-structured interviews are conducted for a number of reasons. First, a certain structure during the interviews ensures that the developed theoretical concepts are actually investigated as various questions that relate to the different parts in the theory frameworks can be prepared prior to the discussions. Accordingly, semi-structured interviews avoid to concentrate on less relevant topics during the discussions and ensure a focus on the defined research area. Second, fully structured interviews are inadequate to this research as a certain level of freedom during the interviews is needed to enquire about specific areas more deeply that come up during the interviews. Third, interviews are not always held with representatives from organisations such as traders or roasters that are primary agents of the coffee supply network. Some interviewees such as scientists, for example, contribute with their individual research findings to the coffee sector, but might not have organisational structures like other core businesses in the supply network. For that reason, semi-structured interviews are preferred over structured interviews as they allow the interviewer to customize the discussions to the themes that matter. An interview with a climate scientist might therefore focus more on the needs for inter-organisational learning and the contribution of scientific expertise to the supply network rather than discussing the processes for knowledge transformation within a company.

The interview structure is based on the theory as presented in chapter Chapter 6: and consists of six different sections as illustrated in Table 7-10. Apart from the heading section, the remainders refer to the different steps of the learning cycle and the theory on inter-organisational learning. Sections “III” to “V” address the identified antecedents that enable the respective steps in the organisational learning cycle. For each antecedent, possible questions for practitioners were prepared to seek detailed information. Accordingly, the data gathered from the interviewees is already semi-structured and allows for drawing conclusion by referring back to the *a priori* developed theory. The stronger the antecedents towards climate change, the more can be argued that a particular step in the OLC is completed by the interviewed agent. Also, if no or little information about a particular activity in the OLC is

identified, it is reasonable to conclude that this part of the learning process is not carried out intensely or at all by the investigated organisation. Considering the semi-structure of the interview, not every prepared question is to be asked as it might be irrelevant to some agents or the interviewee has already provided information on that particular theme. Furthermore, the initial questions might open new opportunities for deeper enquiries through additional questioning and do not claim to be complete. In summary, the selected approach of the semi-structured interview combines the advantages of investigating the *a priori* theories on organisational and inter-organisational learning by collecting specific information thereto, with a certain level of freedom to get new insights into themes that have not been thought of prior to the field research.

Section	Reference to theory	Purpose of data collection	Antecedents	Possible questions for the interviews
I. Heading		Collection of personal and company data		
II. Changing environment	External environment/OLC	Identification of direct and indirect impacts to the organisation or coffee SN		• What are the direct impacts of CC to your organisation? • What indirect consequences have you experienced?
III. Knowledge absorption	First step/OLC	Individual level	Personal vision/values	• What is your personal view about climate change? (Sceptic/intermediate/convinced?) • What influences you?
			Learning	• How do you inform yourself about climate change? Do you view CC as a potential risk? • Do you seek for general information about climate change or do you look for more specific local impacts? Is the interest about climate change limited to your company or to the entire supply network? • Do you actively contact other people to talk about CC? • Do you make formal notes about your knowledge about CC?
			Motivation	• Does increased knowledge help you in your job/with your career? • What is your personal motivation to learn?
			Development & training	Do you volunteer for attending any training courses or workshops about climate change and its impacts?
		Organisational level	Culture/ Commitment	• Are there any (in-house) training courses on climate change? • Does the company encourage you to attend conferences or workshops about climate change?
			Leadership	• Is there a structured process that enables employees to collect information about climate change? • Do superior managers act as leading examples in learning? • Is there a reward system for excellent learning?
IV. Knowledge transformation	Second step/OLC	Group level	Team commitment	• Is there an open discussion about climate change and the impacts on the business and /or supply network? • Who is a member of the discussion group? Also people from external companies/ partners/organisations involved? • Do you exchange information regularly with colleagues? • How do you assess the different levels of knowledge regarding climate change and the impact on the company/supply network? Is there only a random discussion or a particular method?

			Goal setting	• Do you set formal, specific and measurable goals in the context of building a knowledge base about climate change? • What kind of goals do you set? Please name specific goals. Are the goals limited to your company or do they also address the supply network? • What roles play external requirements (legislation, customers, etc) in goal setting?
			Leadership	• Who is initiating and chairing the (official) discussions? • What level of managers is involved in the knowledge building phase?
			Development & training	• Is there a recurring group training/workshop? • What is the importance of external expertise in this CC context?
		Organisational level	Culture/ Commitment	• Do you write down and collect knowledge about climate change from your employees? • What role plays risk management in knowledge transformation? • How do you inform all others about the outcome?
			Leadership	• Is there a person appointed responsible for knowledge building and preparing dossiers about climate change? • What is the main driver of collecting information about CC? • Is a member of the Board involved in the discussions?
V. Knowledge utilization	Third step/OLC	Individual level	Personal vision	• How do you use gained knowledge in your business? • Are you trying to actively change operations management? • Do you think that your personal values on sustainability are matched by the company's/supply network's activities in this area?
			Motivation	Is a personal reward system motivating you to successfully adapt your supply network to climate change?
		Organisational level	Culture/ Commitment	• Are suggestions and knowledge about climate change seriously taken into consideration when making adaptation decisions? • How is knowledge utilised? Detailed reports for the board? Prepared plans to be decided? Or non-specific summaries only? • Do you get feedback about your input to made decisions?
			Competence	• Are the decision makers qualified to make strategic decisions regarding the impact of climate change? • Are decisions made without consulting the experts/staff? • Are they provided with sufficient decisions?

			Leadership	• Is climate change a topic of relevance for the Board? • Is top level support granted? • Is the top level the initiative that facilitates adaptation to CC? • Is the Board more actively involved or rather passive?
VI. Adaptation	Fourth step/OLC	Identification of planned or already carried out activities and strategies to adapt the organisation or supply network to the observed or expected SCCR.		• What are does adaptation mean to you? • What are your adaptation strategies? Can you provide concrete examples? • What general adaptation strategies do you see for your section to adapt to the impacts of CC?
Inter-organisational learning is not specifically asked as the conclusions on agents, self-organisation and emergence, dimensionality, and connectivity can be drawn from the identified network structure and responses to the above mentioned themes.				

Table 7-10: Semi-structure of the interview

7.5.5 Pilot case study

A pilot case enables the investigator to test methodologies, methods and the feasibility of the initial idea of the thesis (Easterby-Smith 2008; Yin 2009). By carrying out a pilot test, the original research concept can either be verified under real-world circumstances or reveal to request for editing. In order to test the research approach and semi-structure of the interview, the pilot case must properly be selected. By choosing a pilot case that in nature is close to the case to be investigated, the researcher may receive valuable feedback that can lead to improvements in the rigour of the overall research design.

Even though 'case' for this research is defined as a supply network, only the single organisation *Ethical Tea Partnership (ETP)* was selected as pilot case in this thesis for a number of reasons. Firstly, ETP is *"a non-commercial alliance of international tea companies who share a vision of a thriving tea industry that is socially just and environmentally sustainable"* (ETP 2012). As a membership organisation it can best give an overview of the learning capabilities of producers, traders, and the entire tea business. Secondly, Kerstin Linne who worked with ETP in previous projects enabled easy access to the organisation. Yet, the researcher followed the same contact-making processes as planned within the coffee supply network. As such, also an email with background information of the research and the request for an interview was initially sent and a face-to-face meeting agreed.

Thirdly, the tea sector is closely linked to the coffee business in terms of global farming, sensitivity of the trees to changes in the environment, and trading structures. Due to these similarities, the obtained results from the pilot case can reasonably be transferred to the coffee sector. Fourthly, ETP already takes a moderating and coordinating role in ethical and sustainability tea projects. It therefore acts as knowledge broker, i.e. as an organisation that creates and shares knowledge throughout its members on determined topics. Likewise, the tea business also recently begun to investigate the impacts of climate change for the sector and set up projects to learn about this newly rising risk such as the *Climate Change Training for Farmers* (Nyambura 2012). Furthermore, both sectors are directly associated via the Coffee & Climate (C&C) project in which ETP took part even though it was initiated by the coffee business. This cross-sectoral learning approach underpins the sufficient selection of ETP as pilot case. And finally, ETP was selected as sole organisation to become the pilot case as due to its moderating role and close relationships with all involved tea businesses, the interviewee is able to take different viewpoints of the SC tiers. ETP's membership structure ensures that most of the information on adaptation to climate change within the tea SC is consolidated at the considered pilot organisation. As such, ETP is able to speak for the entire tea supply

network even though not every detailed position of the different agents can be represented. However, the interviewee can give valuable feedback whether the semi-structured interview addresses all key aspects of SC adaptation to climate change from a practitioner's point of view and whether it is appropriately designed to be used for all different types of organisations within the SN.

The face-to-face interview with ETP was scheduled on 13th August in London and held with Rachel Cracknell (Rachel.Cracknell@ethicalteapartnership.org) who is "Project Manager and Climate Change Expert" at ETP. Kerstin Linne also took part in the meeting in order to triangulate the assessment of the semi-structured interview and research approach. The pilot case aimed to test four key aspects:

a) to assess the overall research approach, i.e. ROs and RQs, and interview method
b) to evaluate the design of the semi-structured interview
c) to get experience in asking questions and guiding an interview to the key themes, and
d) to test the recording device and time frame to be considered for the interviews.

To a)

The debriefing with the interviewee revealed that the case study method was found to be appropriate for identifying the underlying mechanisms that enable a coffee supply network to adapt to climate change. The interviewee confirmed that climate change has recently been put on the agenda to increase the resilience of the agricultural sector. The research to investigate organisational and inter-organisational learning to reveal the processes and mechanisms that enable the adaptation of a supply network was found suitable, but also interesting and innovative. That is primarily because only little efforts have been undertaken on (inter)-organisational learning to develop adaptation strategies for the coffee and tea business. Most of the efforts have project character with a limited number of participants such as under the Coffee & Climate project, for example. Therefore, explicit knowledge on climate change and adaptation activities is very rare and need to be explored by investigating inter-organisational projects and by collecting primary data from the businesses themselves. Accordingly, the interviewee confirmed the research structure to investigate the learning process initially at the organisational level and then at the inter-organisational level. The presented *a priori* models and research questions were approved by the interviewee and did not require any changes. Likewise, the semi-structured interview was assessed to be suitable to collect primary data. On the one hand, unknown sector specifics can be explored further and details on projects and relationships between involved organisations can be revealed. On the other hand, a survey might have reached more organisations, but is likely to have a very little response rate and

lacks the opportunity to gain a deep understanding of sectoral structures and processes. The interviewee confirmed that the pre-emailed research overview and the semi-structure of the interview are helpful to better understand the purpose of the interview and to allow the participant to prepare information in advance. Yet, suggestions were made to shorten the pre-emailed research overview and to emphasise more on the research aim and benefits for the participating organisation. As a result, four presentation slides were cut and the interviewee's benefits were highlighted more clearly. Also, the privacy policy statement was revised by clarifying that data is kept strictly confidential and by ensuring that the participants are made anonymous if they wish so.

To b)

The semi-structure of the interview was understood easily after a short introduction even though the discussant clarified that not every agent interviewed might be able to provide information to each part. The capability to customize the interview however is already considered and part of the research design. It was also revealed that the discussants should only be introduced to the five key chapters and should not be provided with detailed information on the underlying theories (e.g. antecedents, etc…) that might be irritating. In this context, the interviewee reasonably emphasized the trade-off between the time constraint of the interview and the required level of depth for each section. As such, she further argued to limit the number of questions per section and per antecedent to have enough time for new exploratory thoughts. Discussing how precise the possible interview-questions for each section must be, the interviewee argued that the exact wording, e.g. a 'what'- or 'how'-question, is irrelevant for the participant. As long as the theme of the question is understood, each discussant is able to make his or her point. The researcher also noticed that the interviewee consistently brought up inter-organisational topics even though the questions initially referred to organisational matters. The debriefing revealed the difficulty for the interviewee to sometimes distinguish between organisational and network related issues. That is because of the already close relationships with other organisations and the strong link between tea packers and the farmers they purchase from. As a result, most companies already take a more holistic and inter-organisational perspective even if the questions relate to the company scope. It was recommended not to disrupt the interviewee when switching between organisational and inter-organisational information and to leave it to the researcher to sort out the answers during the analysis phase of the research. This procedure was favoured as it avoids double questioning and does not interrupt the interview flow. As a result, the pilot case clearly showed that the interview structure enables the researcher to also collect the required level of

information on inter-organisational learning and that a repetitive questioning in the network context is not necessary.

To c)

Finally, the interviewer got practice in conducting and guiding an interview by collecting useful information that addresses the different parts of the research. The decision to use a recording device turned out to be very practical as it does not distract the interviewer from the conversation by constantly taking down notes. The full transcript of the interview is attached in electronic form to this thesis, and provides all valuable details which in this research are very important.

To d)

The quality of the recorded interview is sufficient to enable an easy transcription, i.e. from a technical point of view, using a recording device is approved. Overall, the interview took about 95 minutes which led to the decision to assign at least one hour to the other interviews.

In summary, ETP proved to be a properly selected pilot case as all key aims were reasonably achieved. The interviewee had a climate related background and worked in the closely related tea business. Her valuable input allowed verifying the research approach as well as the semi-structured interview. Due to the fact that Kerstin Linne provided useful insights into the coffee sector prior to the pilot case, the research approach was already properly designed at the beginning and was externally approved by the experienced interviewee with minor changes only as discussed. Table 7-11 summarises the key revealed aspects that should be considered in preparation for and during the interviews.

Do	Do not
- pre-send research overview	- use scientific language such as "tacit and explicit knowledge" for example.
- use semi-structure of the interview	- speak well or badly about (other) SN agents
- inform yourself prior to the meeting about the interviewee and its organisation	- talk about findings from other interviews to avoid biasing the interviewee (only when appropriate)
- customize the interview	- introduce the models/RQs and detailed structure of the interview as this might be confusing. Only present the five key sections.
- preferably organise face-to-face interviews	- interrupt the interviewee quickly even if he or she diverges from the prepared questions as new relevant information might be explored
- use recording device	- interrupt the interviewee even though information on the organisational and inter-organisational level are mixed during the answers.

Table 7-11: Key aspects to consider during the interviews

7.5.6 Data collection process

This thesis follows Yin's (2009) proposed three key principles for the data collection process. First, a case study data base was created that comprises and structures all information derived from email conversations, notes, recorded interview files, and transcripts for each considered organisation, respectively. In order to receive a proper documentation from the recorded interviews, the digital files were initially transcribed word by word. Then, the researcher edited the first transcript by constructing whole sentences and cutting off filler and double words. In case of non-English interviews (German or Spanish interviews), the researcher translated the polished version into English.

The full transcription process (word by word transcription, edited version, translated version, approval by the interviewee) for the exemplified interview with '4C' can be found in appendix C. As the researcher focuses on the interpretation of the interviewees' responses, no formal method of textual analysis is used. A textual or content analysis is *"a method by which selected items of qualitative data are systematically converted to numerical data"* (Collis and Hussey 2009, p. 164). This quantifying approach normally uses a coding scheme to count particular words and phrases and to then investigate the findings on correlation within a text or between documents. However, the *a priori* framework already enables the researcher to analysis the content in a structured process. Also, the quantification of particular words and phrases is strongly related to the positivist paradigm. Accordingly, the content analysis method is

perceived as inappropriate to this research as it does not enable the researcher to conclude on the underlying mechanisms that make supply networks adaptable to climate change.

The second key principle for data collection refers to the six potential sources of evidence: documentation, archival records, interviews, direct observations, participant observations, and physical artefacts (Yin 2009). This thesis collects primary data from semi-structured interviews and uses secondary data from documentation or archival records such as project reports and company agendas. Accordingly, multiple sources of evidence that aim for convergence are used to investigate the same phenomenon and improve the research validity.

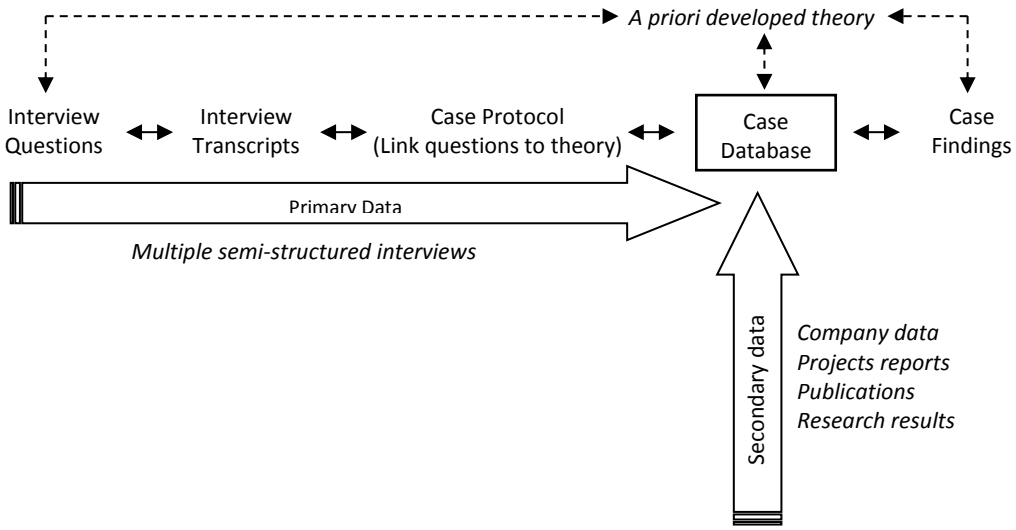


Figure 7-2: Research chain of evidence
Source: adopted from Yin (2009)

And finally, a chain of evidence is maintained as shown in Figure 7-2. As such, no original evidence is lost and a clear link between the case findings and the initial study questions is indicated by following the subsequent stages. The *a priori* developed theories (models on organisational and inter-organisational learning) provide the overall framework for the research and ensure consistency between the research objective, the collection process of primary and secondary data, and the research outcome.

7.5.7 Quality of the research design

Assessing the logic of the chosen research design, four tests (*construct validity, internal validity, external validity, reliability*) have been commonly established in order to evaluate the quality of empirical social research (Denzin and Lincoln 1994; Yin 2009). Table 7-12 summarises the four tests and clarifies how they are applied to this case study. As this thesis has a

predominant exploratory character that includes descriptive elements, external validity, reliability, and construct validity must be addressed. Even though explanatory elements are part of this thesis, internal validity is difficult to establish as cause and effect relationships may not be obvious to identify and cannot be supported by quantitative modelling. However, the developed chain of evidence enables the researcher to conclude on the underlying enablers and mechanisms in the coffee supply network to facilitate adaptation. The overview in Table 7-12 clarifies that each test is considered thoroughly to achieve a rigorous research design.

Test	**Description**	**Elements**	**Phase of research**	**Relevance for this research**
External validity	- Addresses the accuracy of the results that represent the phenomenon studied. - Define the domain to which a study's findings can be generalized - Generalization means analytic and not statistical generalization - Analogy to samples and universes is incorrect	- Use replication logic. Aim to replicate similar answers through the collection of data from multiple case/multiple agents embedded in a single case study - Verify gained patterns	Research design	Even though a single case study was conducted, various organisations and individuals have contributed to the findings. Each interview was transcribed and if necessary translated into English. Also, at least two representatives for each different group in the SN have been selected. In the case of certifiers, traders, and enablers even more organi-sations contribute with data to the identification of the group position.
Reliability	- Demonstrates that the data collection process can be repeated or replicated with the same results by another inquirer - The goal is to minimize the errors and bias of a study	- Creation of "case study database" that comprises all email conversations, notes, recorded files, and transcripts.	Data collection	- Usage of pilot case to refine the research - Pre-send letter of intro-duction and interview guide to informants. - All interviews are recorded electronically to repeat all data accurately. - Data base includes the complete transcripts of the recorded interviews *(see digital attachments D to O).*
Construct validity	Addresses the establishment of the correct operational measures for the concepts being studied	- Use multiple sources of evidence - Establish chain of evidence - Have key informants review the draft case study report	Data collection	- Triangulation is achieved through interviews with 17 agents in one supply net-work. - Also secondary data in the form of project reports is used to triangulate the sources of evidence. - Having opinions from multiple organisations from one group in the SN, extreme and unrepre-

				sentative positions are avoided. - Peer review of the research approach and structure of the interview by a climate change expert (Rachel Cracknell, ETP) from the closely related tea sector as part of the pilot case. - An external specialist (Kerstin Linne) in the field of research assists during the interviews and ensures a rigor research by reviewing the draft results.
Internal validity	- Demonstrate that a particular outcome is caused by a particular variable - The degree to which findings correctly map the phenomenon in question - Only applicable to explanatory research that aims to conclude on cause and effect relationships	- Match different pattern - Explain theory building - Reconcile alternative/ rival explana-tions - Use logic models	Data analysis	Not applicable to this research due to its overall exploratory nature.

Table 7-12: Research quality of the thesis
Source: synthesized from Denzin and Lincoln (1994); Yin (2009); Riege (2003), and Ellram (1996)

Chapter 8: The coffee case study

8.1 Introduction

Coffee growing and drinking began in the Horn of Africa in the 15th century and since then has become the second most traded commodity in the world after oil (ICO 2013). Today, coffee is produced approximately in 55 countries with more than half of the world's output concentrated in the biggest producing countries Brazil, Vietnam and Colombia. The latest available data show that in 2009/2010, some 93.4 million bags worth an estimated US$ 15.4 billion were exported globally. The importance of coffee to the world economy cannot be overstated as it provides employment for ca. 26 million people worldwide in the areas of cultivation, processing, trading, transportation and marketing. Coffee is also a traded commodity on major futures and commodity exchanges, most importantly in London and New York. Besides the importance for the global economy, coffee is also crucial to many developing countries as the export of coffee often accounts for more than 50 per cent of their foreign exchange earnings (ICO 2013).

8.2 The coffee production process

The coffee production process is understood to encompass the whole supply chain, i.e. from the seeding to the roasting process. As shown in Table 8-1, the production process undergoes a number of different steps, beginning with the seeding of coffee trees in the countries of origin and ending with the roasting in the consuming countries. Process steps one to five are highly complex and the most vulnerable part of the supply network as they are directly exposed to supply chain climate risk. Accordingly, all agents should have an interest in learning about climate change and the impacts on the production process in order to develop adaptation strategies that make their supply network as a whole more resilient to changing climate conditions.

Production step	Activity	Description
1	Seeding	Young coffee trees are nurtured for approximately one year in a nursery before they are planted in a farm where they will replace dead or old trees.
2	Planting/Trees	Coffee trees start to produce after 3 years and are considered to be in full capacity after 5 years, then a proper pruning and fertilising is requested to maintain high productivity. This process is very critical as the outcome per tree varies drastically when it is properly managed.

3	Development	The development of the bean begins with the flowering. Depending on the species it takes ca. 9 to 11 months from the flower to a ripe cherry.
4	Harvest	The majority of coffee worldwide is still hand-picked. Harvesting usually lasts two to three months, during which there may be as many as three or four passes in which only the ripest cherries are picked (dependent on species).
5	Wet/Dry Milling	During the wet milling process, the cherries are fermented and de-pulped, leaving two beans in the husk (pergamino). The pergamino is removed from the fermentation tanks, washed, and dried either under the sun in patios or in mechanical dryers. After the coffee has been dried, it is stored in pergamino in fiber bags at a warehouse. By staying in pergamino, the coffee will retain its freshness and its quality will be better preserved. For the dry mill process, coffee is machined in a dry mill to remove its parchment skin. The beans are polished, and any defective beans are mechanically filtered out. The raw, green beans are then re-bagged and prepared for export.
6	Transportation	Green coffee is normally transported in tightly stacked bags or bulk bags that are containerised and forwarded by ship to its final destination.
7	Roasting	The final roasting and grinding process usually takes place in the "Northern" countries in which the roasters brand their product and distribute it to the retailers and end-customers.

Table 8-1: The coffee production process
Source: adopted from (Ecom 2013a)

There is no single best way to make coffee as it depends on the personal preferences, the species of the coffee, and the roasting process which give the hot beverage its flavour and aroma. The two most important species of coffee are 'coffea arabica' (Arabica coffee) and 'coffea canephora' (Robusta coffee). Whereas Arabica coffee accounts for ca. 70-80 per cent of the world's production, Robusta has only a market share of 20-30 per cent. As summarised in Table 8-2, both species have distinct characteristics even though the introduced production process is literally the same.

	Arabica	**Robusta**
Time from flower to ripe cherry	9 months	10-11 months
Flowering	After rain	Irregular
Yield (kg beans/ha)	1,500-3,000	2,300-4,000
Optimum temperature	15-24°C	24-30°C
Optimum altitude	1,000-2,000 metres	0-700 metres
Diseases	Susceptible	Resistant

Table 8-2: Comparison of Arabica and Robusta Coffee
Source: ICO (2013)

Arabica has slightly shorter growing cycles, but must be grown at higher altitudes with much more specific climate conditions. This species has also a lower yield and is less resistant to diseases. In turn, Robusta is much easier to grow as it requires overall less strict climate conditions and can better cope with weather extremes and tree infections. As procurement of Arabica is much more expansive than Robusta, the latter is often used for 'mainstream' (lower quality) coffee blends whereas the former is blended into high quality coffee. In summary, both major coffee species require frost-free growing regions with moderate rainfall and a lot of sunshine in recurring cycles to allow coffee trees to flower and to develop the beans. As shown in Figure 8-1, these rigorous climate conditions are found only in a number of regions in Latin America, Africa, Arabia, and Indonesia

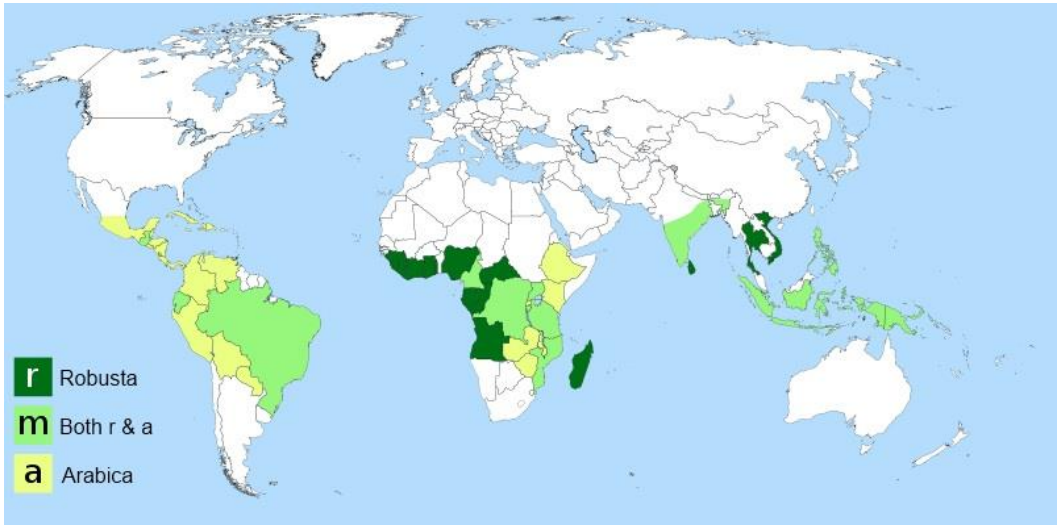


Figure 8-1: Coffee producing countries
Source: Quaffee (2013)

In summary, the coffee production process is location-specific as the quality of coffee heavily depends on the coffee species used and the main species have quite precise ecological

requirements. Because of these distinct characteristics and the multi-step production process, already relatively small changes in climate conditions can have a significant impact on the cultivation of coffee.

8.3 The coffee supply network

Coffee supply chains are highly complex and globally extensive with multiple interacting agents. As illustrated in Figure 8-2, the coffee supply network can be divided into 'core agents' and 'supporting agents'. Core agents are organisations directly involved in the production, processing and distribution of coffee from the raw material supplier to the consumer. They encompass farmers or smallholder producers, traders, and roasters. Supporting agents are not directly involved in the physical growing, distribution, and production processes, but take an advisory, educational, and moderating role. Such supporting agents are, for example producer foundations and public enterprises for international development (*implementers*), standard organisations (*Voluntary Sustainability Standards VSS*), *scientists* and *consultants.*

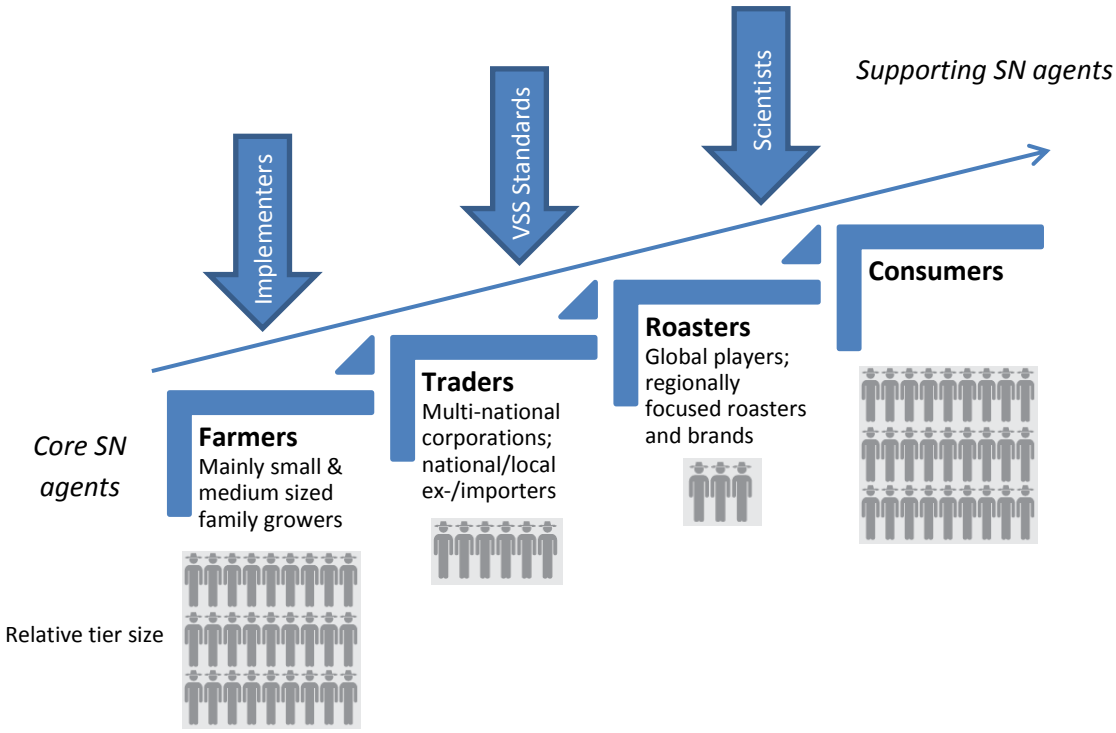


Figure 8-2: A typical coffee supply chain

Even though retailers are also part of the coffee supply network they are not considered in the further analysis for two reasons. First, the interviews with the other organisations (e.g. standards, roasters, etc…) clarified that retailers are not interested in any adaptation activities

at the moment as they see this task to be completed by the organisations more upstream the supply network. Retailers rather focus on the subject of product carbon footprint to comply with their sustainable agendas. As customer demand for adaptation of the coffee supply network is inexistent, retailers currently do not pursue this matter. Secondly, not all coffee is distributed by traditional retailers. The roaster Tchibo, for example, channels its products via own shops as well as a shop-in-shop system through to its customers. In summary, retailers like customers are not directly involved in the adaptation process of the coffee supply network and are therefore excluded from the analysis. However, they might take a more active role concerning adaptation activities for other product groups.

At **farm** level, predominantly small and medium sized family businesses grow green coffee and harvest them individually by hand at very small plantations. This high degree of fragmentation makes it almost impossible to obtain a precise overview and to get in contact with every grower to discuss purchasing matters. For that reason, there exists a very complex system of independent and local **traders** with specific knowledge and long-term relationships to the small family growers as well as national importers and exporters. They consolidate the harvested green coffee and make it accessible to the world market. In most producing countries, the use of these national trading organisations is mandatory as decreed by national regulations. Moreover, the local traders are often part of multi-national trading corporations which further increases the complexity of the supply network. At the **roaster**'s level, large companies such as Nestlé, Mondolez, and Starbucks operate globally whereas smaller roasters such as Cafédirect or Gustav Paulig concentrate their sales in niche or regionally focused markets. As illustrated in Figure 8-2, there are millions of smallholder families at the raw material source and millions of consumers at the end of the coffee supply chain. In-between, multi-national as well as locally operating traders channel the raw material to the relatively small number of roasters who finally prepare and brand the coffee for the end-customer.

The supporting SN agents contribute to the sustainable and ethically approved supply of green coffee. **Voluntary Sustainability Standards** (VSS) such as Fairtrade or Rainforest Alliance, for example, aim to establish 'sustainability standards' and to certify products against them. The standard organisations offer consulting, training and technical support to achieve a sustainable growing process that helps the cultivation to become more sustainable in economic and environmental terms. Even though, certified coffee products become more and more important for traders and roasters to comply with their corporate social responsibility programmes, today only approximately five per cent of global coffee sales are labelled and certified by VSS (Njoroge; interview SMS 2012). Using the existing VSS network and contacts to

small farmers, the standard organisations nowadays offer climate change mitigation as well as adaptation projects in addition to their original services. **Implementing organisations** such as GIZ[11] and private foundations such as HRS Neumann, for example, offer mainly financial support and expertise. As a result, climate change mitigation or adaptation projects in the coffee business benefit from public funding and guidance as well as financial contributions from the private sector. Finally, consultants and **scientists** can also be considered as part of the wider coffee supply network. They provide scientific expertise on the changing environment and how it will likely impact the coffee supply network.

In summary, the coffee supply network has very distinct attributes that differentiates it from other supply networks. Firstly, coffee is a natural and relatively simple product whose cultivation is very sensitive to climate and ecological conditions. It requires good agricultural practices to supply consistent high quality and quantity. Secondly, the raw material suppliers, i.e. farmers, cannot easily be accessed as their highly dispersed smallholder structure prevents direct communication with other tiers in the supply network. And thirdly, the end-customer is relatively price and quality sensitive to coffee. In emerging markets like Russia and China the demand for coffee is rising sharply, contributing to booming demand globally. This is making it difficult for suppliers to maintain the qualitative and quantitative supply as demanded. For that reason, supply network agents (SN agent) at different tiers and functions have increasingly been working together over the last few years. Their collaborative approach aims to tackle the future challenges for the coffee business, such as climate change. Figure 8-3 shows the inter-relationship between the core and supporting agents in the four major projects and programmes that were developed to address 'adaptation to climate change'. These projects have either been completed or are currently still running. To gain an insight into the projects' aims, the progress so far, outcomes achieved, and motivating factors, the key participants of each programme were interviewed. Other organisations that were not being a part of the adaptation programmes, but are also members of the coffee supply network were also consulted, partly to find out why they have not participated in these programmes.

[11] GIZ is a public body that is federally owned by the German government and supported by the German Ministry for Economic Cooperation and Development (BMZ). GIZ offers demand-driven and customized solutions and support services for sustainable development to developing countries.

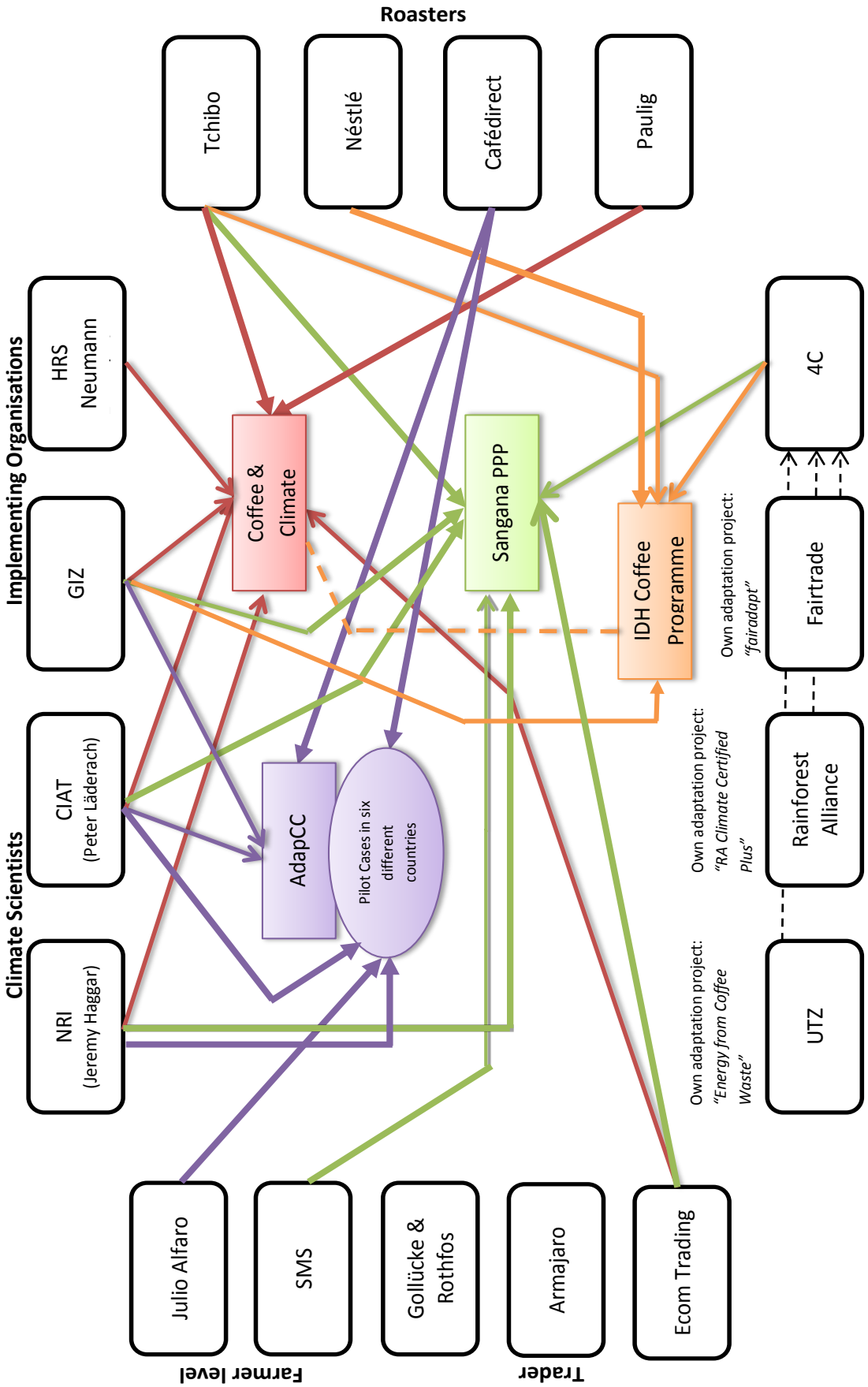


Figure 8-3: Core and supporting agents in the coffee supply network

8.4 Collaborative adaptation projects and programmes

As adaptation to climate change has become a major theme in the coffee business over the last few years, a number of projects and programmes were set up to research resilience to a changing environment. This thesis considers three of the largest collaborative projects and one recently established programme that aim to investigate the impacts of climate change on the producers of origin, to develop adequate adaptation strategies, and to determine implementation procedures at a large scale.

8.4.1 The Sangana PPP project

The Sangana PPP-project in Kenya was a public private partnership[12] project run by an inter-organisational group of public institutions and partners from the private sector. The aim of the project was to identify the impacts of climate change and to develop mitigation as well as adaptation responses that could actually be implemented in the Kenyan coffee business. This region was selected as "the agricultural sector is the second largest contributor to Kenya's GDP, after the service sector. About 6 million Kenyans live on the income from coffee. Since 1989 coffee production dropped from 130,000 metric tons to 50,000 metric tons in 2009. This is partly due to changing climate conditions" (Sangana PPP, 2011). The project roll-out was in October 2008, when Sangana Commodities Ltd., the Kenyan subsidiary of the Ecom Group, and GIZ begun to work on climate change issues in the Kenyan coffee sector. Shortly after the project started, additional partners such as the 4C Association and Tchibo joined the programme. The aim was to develop a procedure to include climate factors into private voluntary standards systems, using the example of 4C in this project case (Sangana PPP, 2011). Further involved SN agents were Jeremy Haggar from the National Research Institute (NRI), Greenwich University, UK who contributed the scientific data on current and future climate conditions and the field agent Bernard Njoroge from Sustainable Management Services (SMS), a subsidiary of the Ecom group. The Sangana PPP terminated 30th September 2011.

8.4.2 The AdapCC project

Adaptation for Smallholders to Climate Change (AdapCC) was a project that aimed to help coffee and tea farmers with the development of strategies to cope with the risks of climate change in Latin America and in East Africa. A pilot initiative was implemented between April 2007 and February 2010 as a public-private-partnership by Cafédirect and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH (German Technical Cooperation).

[12] A Public-Private-Partnership (PPP) is a development programme by the German government that was recently re-named "development partnerships" (www.developpp.de). As the PPP terminology is established and still used by practitioners, this thesis also uses the private-public-partnership term.

Cafédirect has an interest in securing the production of Fairtrade coffee and tea, while GTZ/GIZ fulfils its public mandate to facilitate sustainable development for climate-affected small-holder farmers in poor rural areas. The project was funded almost equally by both partners and started out in six focus countries: Mexico (Más Café-case study), Nicaragua and Peru (CEPICAFE-case study) in Latin America; and Kenya, Tanzania and Uganda in East Africa. Besides the two initiating organisations, the smallholder producers groups involved in the six countries were mostly part of Cafédirect's supply chain. The results and experiences of the project as well as the methods to identify climate risks and the implementation of adaptation mechanisms were made available to all producer groups globally. Additional support was received by scientific institutions such as the International Centre for Tropical Agriculture (CIAT, *Peter Läderach*) and the University of Greenwich (*Jeremy Haggar*) (AdapCC 2013).

8.4.3 The Coffee & Climate project

The 'Coffee & Climate' project was set up to enable all coffee farmers worldwide to effectively respond to climate change and has been running from September 2010 to September 2013. The project was initiated by the private companies Gustav Paulig Ltd, Joh. Johannson Kaffe AS, Löfbergs Lila AB, Neumann Gruppe GmbH, Tchibo GmbH and Fondazione Giuseppe e Pericle Lavazza Onlus, together with the public organisation GIZ. This initiative has been collaborating with further important partners such as the Commonwealth Agricultural Bureaux International (CABI), the Brazilian Agricultural Research Corporation (Embrapa), and the CIAT. As the project is 'pre-competitive' throughout the entire supply network, new partners such as Franck d.d., Ecom Coffee, the Swedish International Development Cooperation Agency (Sida) also recently joined the project (Coffee and Climate 2013). The aim of the project is to enable coffee farmers to effectively respond to changing climate conditions by assembling best practices for climate change adaptation and mitigation into a globally applicable toolbox. "The project combines farmer know-how with state of the art climate change science and builds upon experiences gained within other relevant projects such as AdapCC. Pilot projects in four key coffee regions (Brazil, Vietnam, Tanzania and Guatemala) were designed to test the toolbox in the field and to develop appropriate training schemes for farmers and service providers. The four countries have been chosen as they represent Arabica (Tanzania and Trifinio) and Robusta (Brazil and Vietnam) production, intensive and diverse production systems as well as wet and dry processing" (Coffee & Climate 2013). In February 2013, the initiative launched the 'Coffee & Climate toolbox' for farmers comprising guidelines, training materials and other didactic material.

8.4.4 The IDH coffee programme

The IDH Coffee Programme is a public-private cooperation that was founded in 2008 by the four large companies: Mondolez, Nestlé, DE Master Blenders 1753, and Tchibo, representing annual coffee purchases of 36 million bags which is almost a quarter of the total globally traded coffee. Other partners are the GIZ, the Royal Dutch Coffee and Tea Association (KNVKT) and the European Coffee Federation (ECF). The programme aims to "accelerate and up-scale sustainable trade by building impact oriented coalitions of front running multinationals, civil society organizations, governments and other stakeholders. Through convening public and private interests, strengths and knowledge, the IDH programme helps to create shared value for all partners. This will help make sustainability the new norm and transform markets towards sustainable production and consumption worldwide" (IDH 2013). IDH programmes require cross-sectoral partnerships and effective cooperation with key stakeholders to help the coffee commodity market to become more sustainable. IDH acts as a convener for the different stakeholders and addresses the development challenges mainly through financial resources and the harmonization initiatives. It views itself as a pioneer that pilots new mechanisms for market transformation, and that can scale-up proven concepts to the entire supply network. Besides the focus on coffee, other IDH sub-programmes also work on commodities such as cocoa, tropical timber, tea, soy, and cotton (IDH 2013).

Chapter 9: Analysis of organisational learning

9.1 Introduction

This chapter examines the current learning processes of the 17 investigated organisations in the coffee supply network concerning their exposure to climate change risk and responding adaptation efforts (RO1). It addresses the first part of the first research question and aims to reveal the type of learning which enables organisations to adapt to the risks associated with climate change. Based on the information collected from the interviews and supporting secondary data that were received from the interviewees, conclusions can be drawn on the ability of the agents to carry out the four steps in the learning cycle. As a result, proposition 1 that *"individual organisations in a supply network do not learn about climate change, i.e. understand and adapt to climate risk"* can either be verified or rejected. The analysis follows the interview structure as presented in section 6.4.4 and is applied equally to all agents. The 17 interviewed agents are assessed according to their ability to complete each step in the OLC whereas the assessment does not attempt to analyse the agent's responses quantitatively, but applies a logical process to examine the learning process on the basis of the questions posed during the semi-structured interviews. As presented in Table 9-1, each learning step is evaluated using a four level classification that ranges from very strong (++) to very weak (--).

The four level scale avoids having too many categories and is selected to make a clear statement whether agents learn or not, i.e. upper or lower half and no possibility for a neutral positioning. Double plus indicates that an agent has very strong organisational competences and processes that enable the completion of a particular learning step whereas double minus represents a total lack of the competence and internal processes needed to complete a certain step in the OLC. The decision on how to evaluate every OLC step is based on the evidence found for the associated antecedents, but also considers concrete examples of the 'understanding' and 'adaptation' phases within the organisational learning cycle. As organisational learning might not be fully independent from the community, "++" is awarded if the agent is able to complete an OLC step with very little or no external input, whereas "+" is used to indicate that the completion of an OLC step requires stronger external support.

Symbol	Assessment	Decision criteria	Meaning
++	Very strong	- Evidence for the vast majority of antecedents is found; overall the agent is able to complete the OLC step independently. - Or a detailed practical example for carrying out an OLC step is revealed.	Agent has very strong competence, processes, and structures to complete a certain OLC step. Little or no external support from other agents is required. The outcome is predominantly used internally and is not produced mainly for the purpose of other SN agents
+	Strong	- Evidence for a number of antecedents associated with an OLC step is found. - The OLC step cannot be fully completed without external input.	Agent has good to average competences, processes, and capacities. External support from other agents might be required to complete the OLC step. The outcome is also used by other SN agents.
-	Weak	- Evidence for one or two of the antecedents associated with an OLC step is found. - Findings are not sufficient to complete the OLC step and the revealed competences have only basic or initiating character.	- Agent lacks competence, processes, and structures to fully complete the OLC step. It therefore has only a partial understanding or is unable to complete an OLC step. - Also, the activities in a learning step might be predominantly for the purpose of other organisations.
--	Very weak	- No evidence for the antecedents is found. - No example from practice is identified that indicates competence in the OLC step.	Agent has no ability to complete the OLC phase. It does not understand what needs to be done and so cannot take any action at the OLC phase.

Table 9-1: Assessment criteria for OLC capabilities

The following sections analyse the findings from each organisation in the coffee supply network that was interviewed. To avoid a repetitive discussion, the findings of five SN agents are initially presented in more detail, whereas each organisation represents a different tier and function along the supply chain. The five organisations selected are: Julio Alfaro (farmer), Cafédirect (roaster), 4C Association (VSS standard), GIZ (implementer), and CIAT (scientist). The same pattern of analysis is then used for the remaining organisations, but the findings are only summarised in the form of overview tables together with a short explanation of the key organisational characteristics. The full analyses can be found in the digital appendixes D to O.

9.2 Julio Alfaro (farmer)

Julio Alfaro (interviewee A) is a coffee farmer and advisor to the Union of Coffee Producers Juan Sabines Gutérrez (JSG) in the Lacandonian rainforest in the Mexican state of Chiapas. JSG was founded in 1982 and became an independent cooperative in the late 1990s. JSG has 670 members in 25 communities and produces 10,080 quintals[13] of green coffee on 872 hectares. The educational background of interviewee (A) is in ecological production with additional training in fertility and organic farming. Climate change matters were not part of his university education[14] and only attracted attention when working directly at the farm level. The interviewee's viewpoints are based on his personal opinion and experience, but also consider the perspective of the JSG cooperative which participated in a mutual pilot case study with Más Cáfe as part of the AdapCC project. Más Café is a trading organisation that encompasses approximately 2,250 producers from eight coffee cooperatives in the state of Chiapas (AdapCC 2010).

Findings from the interview

Changing environment

The impacts of climate change are directly affecting the state of Chiapas. Extreme weather events and natural catastrophes happen more frequently, and have become increasingly severe according to the farmers' opinions. They have a direct economic impact as productivity declines due to huge crop losses mainly caused by heavy rain. Whereas rain showers used to be evenly spread over the normal rain periods, nowadays annual rainfall in some territories falls within days and badly impacts on coffee yields. The cooperative lost approximately 60 per cent of its 2012 crop as the combination of heavy rain, cloudy weather and low average temperatures created conditions conducive to plagues, fungi and infestation which in turn led to blight, and eventually unsellable green coffee. This problem is projected to get worse in the future as affected plantations seldom have the opportunity to recover from the blight. Moreover, the soil that is a *"resource of incalculable value"* (interviewee A) was also severely damaged and prevented the farmers from continuing to produce green coffee. Besides the direct impacts of climate change on the plantations, farmers also suffered from loss of infrastructure, houses, apartments and other material assets for production, and even loss of human lives. The farmers noticed rising interest among coffee buyers in understanding the

[13] Quintel is a unit of weight equal to 100 kilograms

[14] The vast majority of farmers is uneducated. However, also multiple agronomists with a university degree work for the farmer cooperative in Mexico and usually also own coffee farms. Therefore, interviewee A is qualified to speak for the smallholder farmer community in Chiapas.

problem of climate change as it negatively affected the quantity and quality of the coffee production. Interviewee (A) therefore concluded that the farm level is the focal point in the entire supply network when dealing with climate change issues.

OLC step 1: Knowledge absorption

Interviewee (A) is highly *motivated* to absorb knowledge of climate change as he is well aware that it will have a strong financial impact and potentially impoverish the country. Rebuilding destroyed plantations and introducing adaptation activities is likely to take a very long time and cannot be implemented by the farmers themselves. In this respect, the interviewee argued that small farmers are always hit the hardest and have become the most vulnerable SN agents to climate change. In particular, the interviewee absorbed knowledge of climate change from two key sources. First, the impacts of climate change were observed and experienced directly in the field as a result of the farming activity. Second, the internet enabled a more formal process of knowledge absorption from general news sites and special websites such as ParticNational Water Board, Semarnat, and Secretary for Environment and Ecology. Besides the internet, knowledge was also absorbed from mass media such as radio and TV, from newsletters issued by the Secretary for the Environment, and from the participation in the AdapCC project *(antecedent learning).* As a result of the continuing working relationship with the project partners, interviewee (A) has been participating in monthly training courses and discussion rounds in Mexico with local AdapCC representatives and more infrequently with senior management from the partnering organisations. The latest discussion round at international level took place in Cancún in Autumn 2012 and focused both on the opportunities of smallholder farmers to adapt to climate change and the support required from the Mexican authorities *(antecedent development & training)*. Within the cooperative, executive directors have begun to address the topic of climate change and organised forums with farmers and local climate experts to raise awareness and sensitise the smallholder families *(antecedent leadership)*. In summary, interviewee (A) has very strong abilities to absorb knowledge of climate change as evidence for 5 out of 6 antecedents were identified.

OLC step 2: Knowledge transformation

Interviewee (A) argued that knowledge sharing does not really take place at farm level due to the smallholder farmer and family-business structures. Yet, within the JSG co-operative, knowledge sharing between farmers can be observed. Farmer representatives exchange information and experiences at meetings, but not in accordance with a structured process. Cooperative structures differ from typical company structures as cooperative Board members do not have the power to instruct farmers and rather rely on their willingness to implement

certain strategies. Accordingly, within co-operatives there is little evidence of *team and organisational commitment* and *goal setting*. *Leadership* is generally weak due to the loose and voluntary structures. Finally, *training & development* was intensified as a result of the participation in the AdapCC project, but it is still sporadic even though the cooperative has recently begun to increase its efforts to share the explicit knowledge with the farmers and train them on adaptation activities. In summary, knowledge transformation is evaluated to be weak as farmers, independently or as part of the cooperative, only occasionally share their experiences and not in a structured way. There is little pooling of information to build up a complete picture of climate change impacts.

OLC step 3: Knowledge utilization

Knowledge utilization at the farm level is difficult. Firstly, most farmers have a very limited education and are unable to transform their experiences of a changing environment into adaptation activities. Secondly, farmers lack the necessary financial resources and technical competence to implement adaptation methods and thus make their plantations more resilient to climate change. Accordingly, no evidence was found from the interview that farmers utilize their knowledge of climate change to adapt their businesses to the experienced impacts.

An example was, nevertheless, found of knowledge utilization within this coffee-growing co-operative. In 2012, the cooperative won the Social Award from Fairtrade that included a financial reward of 20,- USD per exported quintel. Based on the knowledge gained of climate change, strategic choices had to be made to invest the prize money wisely and become more resilient to climate change. A development plan was created that included training courses for farmers and maintenance of technical equipment. As the prize regulations required that at least five of the twenty USD must be invested in improvements and maintenance directly at the plantations, the cooperative's general assembly decided on a renovation plan that included investments in younger, well-nourished and more robust plants to replace older trees. Further investments were made in the use of organic fertilizers, forest diversification and eradication of blight as explained in the adaptation step. These activities were strategically designed to achieve tangible adaptation results for the farmers and to act as a best practice example for the government. If successful, they might lead to improved funding and much wider adoption of these activities by other organisations. In particular, interviewee (A) has already been promoting these adaptation projects to public as well as financial investors with the objective of obtaining long-term contracts for climate change adaptation at the farm level.

In summary, evidence from this particular case showed how knowledge of climate change can be utilized. Prize money received from another supply network partner was strategically spent

on different adaptation activities that helped farmers to become more resilient to climate change. Yet, the development of such adaptation activities was not primarily carried out at the farm level; it was part of a project undertaken in cooperation with other SN agents (e.g. AdapCC). For that reason, knowledge utilization to adapt to climate change is assessed to be weak at the farm level even though it is clearly stronger at the cooperative level. Representatives and selected farmers advise other SN agents on adaptation strategies in mutual projects, but remain unable to adapt their plantations to climate change individually without external support. Nevertheless, the question of *"what to do […] is being discussed very intensely now"* at the grower level (interviewee A).

OLC step 4: Adaptation

As climate change is *"already a reality in Chiapas, in Mexico"* (interviewee A), the farmers are well aware of the need for adaptation activities. In cooperation with GIZ and as a result of an already completed inter-organisational project (Más Café project), the cooperative has begun to implement various adaptation activities since November 2012. First, guidelines have been established to avoid pest infestation and blight. Second, forestation in the plantations has been modified to increase the amount of shade and thus create a micro climate that produces more suitable temperatures for coffee growing. This in turn increases productivity and decreases blight. Third, as farmers normally dry their coffee outdoors, this process has recently become more and more difficult during the periods of unusually heavy rainfall (e.g. January to March). Adapting to this problem, solar drying systems have been developed and installed to allow farmers to dry their coffee in a protected manner and meet the level of quality required regardless of external weather conditions. Fourth, the recycling process for the crop leftovers has been improved to produce organic material that can act as natural fertilizers to fight the problem of blight. Fifth, adaptation to climate change also involves the communication and promotion of the related activities to other organisations and farmer communities to increase the sector's overall resilience to climate change. The final adaptation method does not help the coffee supply network, but the individual farmers, to adapt to climate change. Some of them have begun to diversify their product range and started to grow lemons and avocados to reduce their dependency on coffee production.

In summary, the physical adaptation of the coffee supply network must be implemented directly at the farm level. The interviewee argued that the supply network is most vulnerable at its point of origin and outlined a number of activities that have already been implemented at the plantations. Yet, successful adaptation requires strong commitment and involvement of the farmers to actually change their current agricultural practices. The greatest need for

adaptation in the coffee supply network occurs at the grower level and therefore justifies the decision to assign very strong adaptation abilities to the farmers. The main strategic input on the adaptation was, nevertheless, provided by partnering SN agents. Therefore, the farmers themselves as well as the farmer cooperatives are relatively weak in the OLC steps of knowledge transformation and utilization. Even though the Board members from the cooperatives try to take leadership on climate related topics, they have only recently begun to understand climate change themselves and to set up round tables to disseminate the knowledge throughout the smallholder community. Yet, they also lack skills and structures for knowledge orchestration and therefore also strongly rely on external expertise to establish a learning process.

Analysis summary

Table 9-2 concludes that Mexican farmers are strong in knowledge absorption and adaptation, but have few abilities in knowledge transformation and utilization. Their high knowledge absorption can be attributed to them being directly impacted by climate change. The climate risk factor of extreme weather was observed to lead to crop destruction and a reduction in productivity and the quality of green coffee. Besides direct observations of environmental changes, farmers are highly motivated to adapt their plantations to climate change, are willing to learn and participate in training sessions, and receive some leadership from the agricultural cooperatives to which they belong. Accordingly, very strong evidence is found for the antecedents that relate to knowledge absorption of climate change. For that reason a "++" rating has been assigned to the first OLC step. Regarding OLC step two, knowledge transformation is evaluated to be weak as only evidence for 'development & training' in cooperation with other SN agents was revealed. A coordinated approach to transform tacit knowledge from each local farmer into explicit knowledge of the causes and impacts of climate change only happens sporadically during meetings at the cooperative level. A similar judgement can be made for the third OLC step 'knowledge utilization'. In general, farmers are unable to develop adaptation strategies as they lack a detailed understanding of the causes and future projections of climate change. However, when external knowledge of adaptation is introduced into the farmers' cooperative, it is able to prioritise adaptation strategies and plan their practical implementation in a way that meets local needs. This was revealed in the case of the prize money secured from Fairtrade. Knowledge utilization is therefore rated "-". Finally, the implementation of adaptation strategies to make the supply network more resilient to climate change is very strong at farm level. As the plantations are the most vulnerable parts of the coffee supply network, the interview revealed a number of adaptation strategies that have already been successfully implemented at the farm level.

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	**++**	**-**	**-**	**++**
Enabling antecedents	(5 out of possible 6) - Personal vision/values - Learning - Motivation - Development & Training - Leadership	(1 out of possible 5) - Development & Training ➔ Identification of the need to respond to the impacts and adapt to CC	(0 out of possible 5) ➔ KU was observed in a particular case. Yet, consistent development of adaptation strategies was not revealed	Intense adaptation activities at the farm level as the SN is the most vulnerable at its origin.

Table 9-2: OLC performance of Julio Alfaro - Farmer

9.3 Cafédirect

Cafédirect[15] (CD) is the 9th largest coffee brand in the UK and was founded in 1991 by Oxfam, Traidcraft, Equal Exchange and Twin Trading in order to bypass the conventional market and buy coffee directly from disadvantaged growers in developing countries. In 1994, Cafédirect became the first UK coffee brand to be certified with the Fairtrade mark. Today, all Cafédirect products are 100 per cent Fairtrade as the company works with 38 grower organisations across 12 developing countries encompassing over 280,000 farmers. Cafédirect became a Public Limited Company in 2004 and since then has invested over GBP 4.1 million (more than 50 per cent) of the profit directly into the businesses of its growers. Cafédirect has a strong relationship to the Cafédirect Producers' Foundation (CPF) that has been established to represent and support smallholder tea, coffee and cocoa farmers and their organisations located across East Africa, Latin America and Asia. CPF's work builds on the long-term investment in the social enterprise aspect of Cafédirect with its smallholder partners. CPF is now registered as a UK charity and has members on the Board of Directors who represent the smallholder tea, coffee and cocoa farmers that work with Cafédirect (Producersfoundation 2012 and Cafédirect 2012). The interview was conducted with Wolfgang Weinmann (Interviewee B) and Claire Rhodes (Interviewee C).

[15] Even though Cafédirect does not have own roasting facilities, and has also a trading function, the brand Cafédirect is similar to those from other roasters (e.g. Tchibo). Therefore, Cafédirect is classified as roaster in this thesis, as it certainly differentiates much more from traditional traders such as Ecom, for example, and with its brand name is rather understood as roaster by the end-consumers.

Findings from the interview

Changing environment

Cafédirect is already impacted by climate change as maintaining the sourcing of quality coffee is one of Cafédirect's biggest concerns. In the highly competitive UK market, consumers do not accept lower quality products from the Fairtrade brand. Extreme weather events such as the prolonged droughts in East Africa, the hurricanes in Central America and the Nino/Nina effect in Peru have become an environmental trigger for CD as it sources approximately 50 per cent of its coffee from these regions. Hurricane Stan, for example, affected the coffee supply from Mexico because it happened just at the beginning of the harvest season in November destroying a significant portion of the harvest and disrupting transport at this critical time. Interviewee (B) argued that extreme weather events have become more frequent which has caused increasing discussions within the company about the impacts and possible adaptation approaches. However, CD will not tolerate a lowering in quality. By having a wide, globally-spread base of grower communities from whom to source it expects to be able to maintain quality. *"So it's not something that immediately impacts us, but of course in the long term [it may]"* (interviewee A).

OLC step 1: Knowledge absorption

On the basis of knowledge absorption at the individual level, the *personal visions and values* of the interviewees reveal a belief that climate change is happening even though the factors that drive climate change remain unclear. Based on their educational background and work experience in environmental management, the members at CD appear to be very open minded towards research on climate change. Both interviewees *learned* about the impacts of climate change when speaking directly to producers who reported observations of definite changes in their environment such as heavier and less predictable rainfall. Interviewee (C) stated that *"you see a lot of farmers saying that when they were young we used to know that the rains would start on this day, now we cannot tell and in Kenya they had a frost for the first time on their fields, last year".* Relevant information is gained through participation in workshops with farmers who present their experiences of extreme weather events that made a strong impression as being unique or substantially different.

Interviewee (B) claimed that he did not have to and never will become a climate change expert even though the nature of his work requires continuous updates on the phenomenon. In order to overcome the complexity of climate change, CD officials learn from a bottom-up approach because otherwise the organisation might suffer from never ending scientific research without any impact at the farm level. Therefore, it is very important for CD to get 'grounded

knowledge' of climate change in order to offer the farmer communities support with the adaptation of their agricultural practices to climate change over next 20 years.

Concerning the individual *motivation* to learn, it is all about working with the farmers and putting projects in place that help them find solutions. Interviewee (B) has 25 years on the ground experience and for him, climate change is not an isolated phenomenon. Rather one has to adopt a holistic approach to climate change by seeing how it links to environmental management capabilities. He further argued that climate change is something that CD has to face because people cannot leave a legacy for the next generation to sort out the problem. On a personal level, Interviewee (B) feels very passionately about climate change and aims to find ways to support adaptation so that the small growers can produce the necessary quantity and quality in the future. However, Interviewee (C) also argued that the coffee community currently offers increasing financial support on climate change projects which motivates the organisation to intensify its activities in adaptation and mitigation projects.

At CD, there is no formal staff training on climate change even though in 2007, interviewee (B) took part in a course on environmental change that helped him to determine an overall environmental strategy that links the private sector with the public sector and Non-Governmental Organisations (NGO). Headquarter management in London learn about climate change during presentations given at the regular 'lunch time learning sessions' that equip each employee with at least a basic knowledge of climate change. These learning sessions are either initiated and moderated by interviewee (B) or another executive officer from a different departmental unit (*antecedent training & development*).

In order to foster knowledge absorption at the organisational level, CD's *commitment* to individual knowledge creation is based on the assumption that scarcity and availability of coffee beans will become an issue for the future and affect competitiveness. As such, managers need to know how the business is affected and who in the market does what and why. For that reason, CD did an environmental assessment of the company that included climate change, but initially focused on the mitigation aspects. Even 'adaptation' was not a part of the assessment, *"it was clear that as a social enterprise with a direct link to the producer communities, it became apparent that they are two sides of the 'climate change' coin"* (interviewee B). Now that climate change is perceived as a potential risk, CD executives decided to take the *lead* on researching its possible impacts. Their focus is not on theory and academic studies, but on field research, i.e. what is actually happening to their farmers. CD employees from all departments including finance, administration, or marketing, are often given the chance to go out to producer organisations to hear about the topic, to observe, and

to ask questions even though they are not experts. As such, CD's culture towards learning is very open and encourages people to absorb as much knowledge as possible from grower communities, but also from outside the company. However further investments in institutional capacity are not a priority at the moment.

In summary, evidence was found that at CD the six antecedents identified in theory at the individual as well as organisational level do enable knowledge absorption. The interviewees identified the three factors, leadership, motivation, and organisational commitment, as most important in the process of knowledge absorption. So, *"if you cannot lead on a topic, it will fade away"* (interviewee B). Personal perception of climate change is ranked highly as a motivator that drives leaders to get people behind the project and make it happen. It was also revealed that in other sectors it is principally mitigation activities that are the main source for funding whereas in the coffee supply chain, adaptation also yields monetary benefits. Aiming for funding from both ends, the interviewee also highlighted the interdependency between mitigation and adaptation. The extensive use of fertilizers for example, is likely to make the coffee trees more robust to climate change, but will also increase the amount of emitted greenhouse gases. In summary, without organisational commitment all created knowledge remains theory and *"a fluffy thing on a strategy paper"* (Interviewee C). Institutional commitment is therefore required to drive knowledge creation and support the learning process at the employee and organisational levels.

<u>OLC step 2: Knowledge transformation</u>

At the group level, CD organises numerous internal sessions to train its staff on all relevant topics. There is no specific workshop on climate change and no team meetings that set clear objectives on this matter. The regular business sessions are known as 'lunch time learning' (LTL) sessions or in-team meetings and aim to up-date employees in the headquarters on different topics to provide a general knowledge base for all non-experts. These LTL sessions are a good opportunity to transfer knowledge of climate change throughout the headquarters as CD does not want to distract people from their defined functions. Attending the LTL sessions is voluntary and everybody is encouraged to present his or her work in an informal atmosphere that fosters interesting and stimulating discussions. Interviewee B is responsible for the sessions and leads the dissemination of knowledge of climate change to enable every member of staff to understand what is happening and how these changes relate both to company strategy and their own work. As such, explicit knowledge is generated at the group level around different topics including climate change that is backed up with concrete and tangible findings from work on the ground with the farmers. Besides the LTLs, CD has a more

formal and structured meeting every month to inform and update all employees about the latest activities which may also comprise climate change projects. From a headquarters' point of view, company training is an important way of sharing expertise on environmental changes and improving understanding of the external input factors and the consequences for the entire organisation of climate change. For that reason, interviewee (B) preferably sends out the London office staff to the field to experience the impacts of climate change from the farmers' perspective.

At the organisational level, knowledge transformation at CD aims to consolidate tacitly held knowledge from each expert, make it explicit and present it in an easily-accessible form. This also means repackaging more scientific knowledge into a language that external agents such as farmers can easily access and then use to inform other farmers. As such, CD *"is looking at it from the producer's perspective and put out the information in forms that can resonate with different target audiences"* (Interviewee C). Internally, as in most organisations, some people have more advanced knowledge that needs to be made accessible to the entire organisation. CD generated knowledge on climate change (and other topics) is stored in an open server to allow every employee to access it quickly. Interviewee (B) pointed out that it has not always been easy to find the information required, as it is stored in a pragmatic manner and not in a well-structured, academic-style data base. Information is processed internally and externally mainly in the form of presentations and not in large document files with exception of public reports. This method of storing and disseminating information nevertheless allows CD to provide primary data on climate change for new recruits. GIven that CD's headquarter is based in London, interviewee (B) emphasised the importance of suitable knowledge storage and access by mentioning that *"it is really important, because especially in the labour market like London, the high rotation of the staff [is] normal".* This makes the transfer of information from staff who are leaving to new staff at the headquarters critical. There is always a team dealing with climate change and sustainability and this group working helps to assimilate new employees into CD's knowledge absorption and sharing process.

Climate change adaptation is also part of the annual review. This report is called the 'Gold Standard' and represents the values and principles on which CD's business is run. The environmental section of that standard also focuses on the growers and informs the whole organisation as well as external agents about previous and current adaptation projects. The latest report in 2011, for example, contains particular information about the AdapCC project and the latest reforestation project:

- "Cafédirect invests in co-financing innovative projects such as Reforestation Sierra Piura. While the reforestation provides recognised environmental and economic benefits to communities most in need, this particular project also invests part of the revenue to fund climate change adaptation for our coffee farmers. This part of the project allows us to continue the important work started in 2008 during Cafédirect's AdapCC project in partnership with the German Technical Cooperation. The reforestation and adaptation project also makes us more visible internationally. Most recently, we won the ProClimate prize for 'best practices for climate adaptation and mitigation' organised by the Progreso Network, a Dutch NGO. This award makes us proud and encourages other organisations in many parts of the world to take part in similar initiatives" (p. 2).
- "Since 2010 we've been working with our coffee partner CEPICAFE to support its farmers to adapt to climate change, firstly via our AdapCC project and now via a unique reforestation project. For the coffee farmers of CEPICAFE, 10% of the income from credit sales will fund climate change adaptation activities on their farms" (p. 13).

This approach is in line with CD's organisational commitment to being an open and a transparent company that shares information with other organisations. Due to the small size of the firm, CD benefits from partnering particularly in developing countries and uses partnerships to transfer knowledge of climate change. So knowledge transformation within the organisation occurs not only through sharing internal expertise, but also through ingesting externally generated knowledge

Considering the *antecedent leadership*, CD's management Board is informed about all climate change adaptation activities in accordance with the 'Gold Standard'. The Board of Directors has signed off the agenda on climate change and influences the adaptation strategies as two Directors are from the producer side and have long-time 'on the ground' experience. In conclusion, top-down management is a key part of CD activities to tackle the impacts of climate change. However, it has to make the financial case for climate change adaptation projects.

In summary, both interviewees argued that the right tools and systems need to be in place to foster knowledge transformation from tacit to explicit knowledge. Interviewee (B) pointed out that the key to successful knowledge transformation is communication in a language that everybody understands according to his or her background. In turn, Interviewee (C) acknowledged that there is also a risk in sharing information about climate change adaptation

with other businesses as it might erode any of Cafédirect's competitive advantage in this area. The organisation understands that it has to be careful when making its 'climate change' knowledge public even thought this is part of the organisational culture.

OLC step 3: Knowledge utilization

At both the personal and organisational levels, there is strong motivation to make use of the organisational knowledge in the formulation of adaptation strategies for the coffee supply network. According to interviewee (C), it is important to invest in knowledge creation now and to show that there must be SC adaptation for the future, as plans are currently being prepared for the redesign of supply chains over the next 5 to 10 years.

At CD, knowledge of climate change is not only used to make the company more resilient to climate change; it is also consistent with its social enterprise business model, one objective of which is to develop adaptation strategies that help the farmers and sustains the existing sourcing network. When developing adaptation strategies, CD is always committed to the two key objectives of securing the supply-chain for the long term and living up to the Gold Standard mission. Interviewee (B) underpins this approach by arguing that *"if farmers can adapt to the impact of climate change then that surely is a positive outcome of the whole business model".* CD believes that it must start to take action on the ground and claims to have the competence to be actively involved in developing adaptation strategies. Therefore, the organisation set up an impact and sustainability programme (Producer Partnership Program) in 2009 and recently handed it over to the Cafédirect Producers' Foundation to support adaptation to climate change in cooperation with farmer communities. CD aims to provide an adaptation framework and supporting resources (financial; and implementing support staff) that can then be used by all farmers to prepare for the projected environmental changes. It bases its strategic decisions on organisational knowledge and insists on helping farmers to become more resilient to climate change. In summary, *competence* and *leadership* are rated as highly important in the use of climate-change-related knowledge. CD actively acquires, processes and disseminates relevant climate data rather than simply having ideas about climate change on paper only. Finally *organisational commitment* is also necessary as otherwise individual people who drive adaptation to climate change might become demotivated if their efforts are not backed by the organisation. At an organisation level, CD has developed a good understanding of climate change impacts despite having only a handful of employees specifically dealing with this matter. For that reason, CD is assessed to be strong in knowledge utilization.

OLC step 4: Adaptation

CD is predominantly involved in collaborative projects with other agents to make the entire supply network more resilient to climate change. Due to the size of the organisation, limited resources are available to actually put adaptation actions in place. CD's strategy is to combine mitigation and adaptation activities to use the carbon emissions trading market as vehicle to generate funding for adaptation projects. Carbon credits gained from mitigation efforts can then be reinvested in adaptation initiatives. CD is actively involved in the AdaptCC project and makes a strategic investment in activities to enable farmers to cut carbon emissions as well as adapt to climate change. Besides the AdapCC project, CD received a grant from Comic Relief to fund six producer communities in an analysis of environmental risk and appropriate adaptation strategies.

In summary, CD put a lot of effort into supporting farmers to adapt to climate change, even though adaptation targets are quite vague in comparison to other company targets. Currently, adaptation activities are measured in terms of how many farmers are actually engaged in the projects and how tangible the financial investments are. Overall, CD is assessed to be weak in the final OLC step, as adaptation activities are still not revealed to be necessary at a corporate level, but rather at the farm level. Nevertheless, interviewee (B) stated that *"it is frustrating to see over the past ten years' time how little we seen the game change in terms of adaptation. So lots of conferences, lots of commitments or pledges and new funds being set up, but how much is trickling down to the small grower communities day in and day out? I would put a big question mark on it."*

Analysis summary

Cafédirect as a medium-sized company in the global coffee market and with a strong ethical business model has good competences, structures and processes in place to understand climate change and develop appropriate adaptation strategies. As shown in Table 9-3, CD is very strong on the 'understanding' part of the OLC and has very good knowledge absorption as well as transformational abilities. Evidence of all relevant antecedents in the first two OLC steps was found. Knowledge utilization however is rated strong as CD's relatively small size hinders the organisation from developing adaptation strategies that make the organisation itself more resilient to climate change. Finally, although CD is in close relationship with its farmers via the 'Producer Foundation', it does not actually implement adaptation measures on the ground. This process is left to the farmer communities and is only monitored by CD. For that reason, the last OLC step is assessed to be weak as CD takes only advisory and training roles. In conclusion, CD is involved in all four OLC steps, but is clearly much stronger at the

knowledge creation end and follows a more collaborative approach with external organisations to mutually utilize the knowledge they have gained.

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	**++**	**++**	**+**	**-**
Enabling antecedents	(6 out of possible 6) - Personal vision/values - Learning - Motivation - Development & Training - Culture/ Commitment - Leadership	(5 out of possible 5) - Team commitment - Goal setting - Leadership - Development & Training - Culture/ Commitment	(4 out of possible 5) - Personal vision - Motivation - Culture/ commitment - Leadership	Only supporting role to implement adaptation projects at the farm level

Table 9-3: OLC performance of Cafédirect

9.4 4C Association

4C Association is a standard organisation that brings together stakeholders in the coffee sector to address sustainability issues in a pre-competitive manner. This membership organisation was set up in 2003 with support from the German Ministry for Economic Cooperation and Development (BMZ), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the German Coffee Association (DKV). Shortly afterwards, the Swiss State Secretariat for Economic Affairs (SECO), the British Development Cooperation and the European Coffee Federation (ECF) joined the project. To date, over 260 members have already joined the 4C association, including coffee farmer organisations; traders (importers and exporters); industry (coffee roasters and retailers); and civil society organisations. This global community agreed on 'The Common Code for the Coffee Community' as a standard for the industry that helps to achieve the key goal of 100 per cent coffee sector compliance with baseline sustainability norms (4C 2013). In order to achieve this goal, 4C takes three roles. First, 4C is a baseline sustainability standard for coffee. Second, it aims to cooperate with other standards that are more demanding, such as 'UTZ-certified', 'Rainforest Alliance' and 'Fairtrade'. As they have become 4C members in the meantime, 4C has become a more general sustainability standard. The third role is dedicated to a global platform concept for everything that has to do with sustainable coffee production and distribution. The platform adopts the multi-stakeholder approach to promote this 'broader sustainability agenda' that aims to find solutions for the key challenges within the coffee sector. It comprises a number of initiatives relating to finance, pesticides, aging farmers, and also climate change. In order to achieve its goals, 4C has a

headquarters in Bonn, Germany and five regional offices in Brazil, Uganda, Kenya, Vietnam, and Indonesia with a total staff of 15 experts. Interviewee (D), a geographer, is 'Funding Manager' with 4C and has many years of work experience in development aid with a specialisation in agriculture.

Findings from the interview

Changing environment

Being an international platform and agency providing a baseline standard in the coffee business, 4C is a business organisation which is not involved in the physical production and distribution of coffee and so is not directly impacted by climate change. Climate change, however, has an indirect impact on 4Cs activities as it might play a stronger role in 4C's broader sustainability agenda. This agenda addresses various sustainability-related topics, but the organisation has not yet determined any goals and activities on climate change adaptation. Decisions on climate change issues and the allocation of human and financial resources towards climate change will be decided by all 4C members at the next general assembly in late 2013.

OLC step 1: Knowledge absorption

Interviewee (D) absorbs knowledge from publicly accessible sources such as newspapers and reports, but also reads academic papers to get the latest scientific information about climate change and its impacts on the coffee business he would not call himself a 'climate guru' even though he is confident that climate change is happening as he generally believes in the scientific reports and future projections. The interviewee has not experienced climate change himself and pointed out that he is unsure about the opportunities mankind has to mitigate or adapt to climate change (*antecedent personal values/vision*). In addition to the available reports, the interviewee gained knowledge on the impacts of climate change directly from farmers as part of the Sangana PPP project. Even though he was not on the ground to observe the impacts, the resulting project reports were disseminated at several conferences which also offered the opportunity to speak to climate experts and affected SN agents. The relatively small size of 4C requires the absorption of knowledge from external sources that may also include the purchase of expertise from climate scientists such as CIAT, for example (*antecedent learning*). As 4C is currently in transition from a pure baseline standard to an interactive platform, climate-related activities are both recommended on a 'top down' basis by the 4C Board and proposed on a 'bottom up' basis by members. Yet, support for climate change adaptation could be stronger as some 4C Board members and member organisations set priorities other than climate change related adaptation projects due to the limited resources

available. Therefore, *leadership* is weak as no formal *training & development* activities on climate related issues were revealed at 4C. The interviewee is motivated to play a more active role in climate related matters, but has not been prioritising adaptation projects due to a lack of goal setting by the 4C Board and the fact that 4C members previously had other interests.

In summary, 4C has weak capabilities in knowledge absorption about climate change and its relevance to the coffee business. Even though the interviewee read a number of reports and papers and also believes in climate change, poor *leadership* and *training & development* indicate a rather low level of knowledge absorption on climate change adaptation. Despite the motivation of the interviewee to work on climate change projects, there was very little evidence found that 4C is committed to facilitate adaptation.

OLC step 2: Knowledge transformation

Interviewee (D) argued that it is necessary to understand that the perception of climate change varies throughout the supply network. Concerning 'adaptation', perceptions are quite different, especially about the need to do something and depend on where people are placed, even within one company. As a result, opinions may vary depending on whether people actually deal with the farmers or have an office-based role. Therefore, the interviewee concluded that the transformation of knowledge obtained from different sources is difficult. Some partners argued that unseasonal rains have always occurred and are nothing special whereas others related these observations to climate change. To 4C, it remains difficult to determine the causes, impacts and even adaptation mechanisms for climate change as their scale and implementation is hard to measure. However, 4C generally understands that it has a role transforming knowledge of climate change and disseminating the findings to its members. However, its relatively small size and limited capacities make it difficult for 4C to transform knowledge of the impacts of climate change to the required level.

Within the organisation, regular team meetings are held to make individual knowledge explicit to all the employees. All climate-related documents are uploaded to an internal document management system (DMS) that is accessible by all members of staff (*team commitment*). Yet, the interviewee claimed that the maintenance and updating of the DMS could be better and due to time constraints, employees that work on non-climate topics might be poorly informed. Considering the antecedent *organisational commitment*, 4C has no plans as yet to establish a climate department that would dedicate its full resources to climate change mitigation and adaptation projects. However, at least four meetings are scheduled annually to take place directly in the different coffee growing regions to synthesise knowledge of the impacts of climate change between farmers, traders, and roasters. The interviewee revealed no special

support from 4C Board members (*leadership*) and explained that there was no formal goal to build up a knowledge base for SN adaptation (*goal setting*).

In summary, 4C's knowledge transformation abilities are weak. There are no in-depth discussions within the organisation about climate change and possible adaptation projects and strategies. Despite some regular meetings in Bonn as well as in the different coffee producing regions, specific goals were neither set nor could any leadership qualities be identified. The knowledge base concerning climate change and adaptation is therefore small and often project-specific, such as in the case of the Sangana PPP, for example.

OLC step 3: Knowledge utilization

In terms of adaptation, interviewee (D) is convinced that the only possible way to make it tangible for the sector is to combine it with the existing development of standards (Fairtrade, UTZ, etc…). 4C is not aiming to create another standard for adaptation, but to look for overlaps and synergies between adaptation and the current range of standards. Today, the mutual agreement to work on carbon measurement is stronger than on the development of adaptation projects as the outcome for the latter remains unclear whereas carbon footprinting can build upon similar initiatives in other agricultural sectors. This problem is exacerbated by the fact that a number of private organisations have not decided on their role in adaptation and wish to follow rather than pioneer SN adaptation. This conflict makes it difficult for 4C to allocate fees to different projects. Whereas some members such as the Neumann Group are active in adaptation to climate change, others aim to spend their membership fees on mitigation projects and activities that have a short-termer return on investment. They question the 'added value' of adaptation and suggest that extra funding would be needed to sponsor adaptation projects that would preferably also have a mitigation component. Despite this uncertainty about its role in competitive and pre-competitive settings, 4C generally supports climate change adaptation projects. However, as competition amongst non-governmental organisations and supporting agents in the coffee supply network is relatively high, the different standard organisations and NGOs have not yet been pulling together in the same direction on climate change adaptation over the last few years.

Interviewee (D) argued that 4C views itself as an intermediary that does not go into the sector to establish a baseline standard for climate change adaptation, but could have a role in building up a network of contacts to organise adaptation. However, the utilization of gained knowledge of climate change has been difficult for 4C as the outcome is hard to predict and other priorities were set by the members in the past. This partly explains why a 'climate change working group' that had been initiated a couple of years ago was shut down. It might

be re-established following the next general assembly in order to address the rising interest on climate change amongst 4C members.

In summary, 4C has few capabilities to use its small knowledge base for adaptation planning. The interview revealed a general organisational commitment to moderate and facilitate adaptation activities, but also found no evidence for the antecedents *personal vision, motivation, competence* and *leadership* required for SN adaptation. The moderating role of 4C and the need to fund adaptation projects from external sponsors puts the organisation in a position that it currently lacks the power to utilize the knowledge gained on climate change and to develop adaptation strategies. In conclusion, 4C's knowledge utilization capabilities at the organisational level are weak even though the platform concept could play an important role in inter-organisational learning.

OLC step 4: Adaptation

So far, 4C has not been very active in adaptation to climate change. The organisation only took part in the Sangana PPP, but was not involved in the implementation of adaptation practices on the ground. Accordingly, 4C is very weak in the final OLC step 'adaptation'.

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	-	-	-	--
Enabling antecedents	(2 out of possible 6) - Personal vision/values - Learning	(1 out of possible 5) - Team commitment	(1 out of possible 5) - Organisational commitment	No active involvement in adaptation activities. No consultancy revealed.

Table 9-4: OLC performance of 4C

Analysis summary

The analysis of 4C's organisational learning process revealed that the organisation has an overall weak performance in every OLC step as summarised in Table 9-4. Despite its membership construct that has been widely accepted and attracted nearly all important organisations in the coffee business, 4C primarily takes a moderating role with few activities in the various OLC steps. Its strongest OLC step is 'knowledge absorption' as evidence for two antecedents was found whereas the implementation of adaptation activities is not part of 4C's role. In general, the interviewee showed interest in climate related activities, but also argued that the small size of the organisation prevented him from collecting more information about

the changing environment for coffee production and from transforming this knowledge to an agreed formal 4C knowledge base. Consequently, 4C is unable to utilize gained knowledge for adaptation strategies. In conclusion, 4C was involved in the Sangana PPP and recently joined the IDH programme, but predominantly retained its platform role with few internal learning capabilities and a strong dependence on other SN agents.

9.5 GIZ

The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) was previously known as German Technical Cooperation (GTZ), an international cooperation enterprise for sustainable development. Its corporate objective was to improve people's living conditions on a sustainable basis. GTZ was owned by the Federal German Government and supported the German Ministry for Economic Cooperation and Development (BMZ) and other international clients in pursuing its development-policy objectives. GTZ worked on a public-benefit basis. All surpluses generated were channelled back into its own international cooperation projects. In January 2011, GIZ was formed. It brings together the long-standing expertise of the Deutscher Entwicklungsdienst (DED) gGmbH (German development service), the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH (German technical cooperation) and InWEnt – Capacity Building International, Germany (AdapCC 2013). With its global network and international experience, GIZ offers demand-driven and customized solutions and support services for sustainable development. A particular service addresses 'Environment and Climate Change' and includes the identification of the extensive range of causes of environmental risks. It advises its partners on the implementation of adaptation measures by using its "long-gained experience in a wide range of countries, technical competence, experience in moderation and methodologies, know-how on organisational development, environmental communication and conflict management" (GIZ 2013a). Finally, GIZ aims to modernise environmental policies at all levels and advises regional environmental co-operatives on how to embed environmental protection in their strategies and policies. Interviewee (E) is 'Team Leader for Social and Environmental Standards' in the agricultural sector with a particular focus on coffee, tea, and cocoa. Interviewee (F) is 'Project Manager for Strategic Alliances' at GIZ, such as that for 'Coffee & Climate' for example.

Findings from the interview

Changing environment

Like other supporting agents, GIZ is not directly impacted by climate change as it does not grow green coffee or trade the final product. Its advisory and supporting role leaves GIZ indirectly affected by climate change. Observations of a significant decline in the quantity and quality of coffee such as in the case of Guatemala, for example, require more and more of the advisory services on sustainable agriculture offered by GIZ. As the future projections and impacts of climate change remain uncertain, GIZ requires more resources to fulfil its advisory role across a global and complex supply network. Additional public-private-partnership projects will enable GIZ to evaluate the variable impacts of climate change on the coffee supply network and to develop local solutions for adaptation.

OLC step 1: Knowledge absorption

Interviewee (F) absorbed knowledge of climate change initially at university and during field projects in the coffee business in Honduras when she personally observed the impacts of a changing environment, e.g. landslides and pest infection. At a personal level, climate change has been on the agenda of interviewee (E) since 2003, when he worked at the Centre for Marine Tropical Ecology and dealt with rising sea levels and other climate change related impacts. Knowledge was also absorbed from external sources such as CIAT and NRI. Based on their future climate scenarios, the interviewees generated the knowledge that about 40 per cent of current Arabica coffee production is projected to disappear by 2050 in the absence of any adaptation to climate change. The interviewees keep themselves actively informed through the participation in projects such as 'Coffee & Climate'. They also contract external experts to provide research on climate change and its impacts on coffee production. Regular meetings with climate change experts within GIZ also offer new insights into the impact of a changing environment (*antecedent learning*).

With reference to *personal vision/values*, Interviewee (E) is convinced that *"climate change is not something that is going to happen the year after next, or around 2050, it is something that is affecting us in a massive way right now"*. In the context of coffee, it is already clear that a number of areas are currently having to adjust to changing climate conditions, i.e. coffee can no longer be grown at some altitudes without great difficulty and/or adaptation activities. With their academic background and long-term work experience in the field, the interviewees are highly motivated to help farmers to improve their living conditions and adapt their plantations to the impacts of climate change in a sustainable manner (*antecedent motivation*).

In conclusion, GIZ is very strong in knowledge absorption about climate change. The general organisational culture is based on the principle of offering customized support in sustainable development. Even though both interviewees did not provide much information on the antecedents *development & training*, and *leadership*, the nature of GIZ's mission and organisational structure encompass both factors. The interviewees receive regular updates from sub-contracted climate and agricultural experts as well as from internal GIZ specialists who provide information about climate change for the entire organisation (as part of *development & training*). General support from top management on climate change is part of GIZ's standard culture and the position of interviewee (E) as team leader ensures that climate change issues are adequately addressed for the coffee business (*antecedent leadership*).

OLC step 2: Knowledge transformation

Climate change is a broad topic at GIZ that is researched by a number of scientist and practitioners. Information about climate change is frequently disseminated across the organisation by various means such as by the special working group on 'Agriculture and Climate Change'. As part of the organisational structure, GIZ headquarters receives regular updates from the so-called 'Professional Associations' and 'Sectoral Networks' which work directly in the countries and report back the latest knowledge on climate change, its causes and impacts (*antecedent culture/commitment*). Accordingly, both interviewees are well informed about the environmental changes in the agricultural sector via internal communication channels.

There are no specific goals set concerning climate change even though GIZ has established a climate section (section 47) that deals with all climate-related projects and provides all other GIZ sections and programmes with the necessary information about climate change. The multi-million Euro budget is mainly spent on public-private-partnership projects. As part of the different projects (e.g. Coffee & Climate, etc…), various local expert committees were also formed to bring together different areas of local expertise, feed the acquired knowledge back to the headquarters (*antecedent team commitment*) and to disseminate the findings to the farmers as well as the national administration. As in the first OLC step, *development & training* and *leadership* are not explicitly highlighted by the interviewees as they are understood to be a normal part of their daily work.

In summary, GIZ is very strong in knowledge transformation and has a de-centralised network structure and expertise that enables the organisation to create a central knowledge base and develop a detailed understanding of the future climate, its likely impacts on the coffee farmers, and possible adaptation strategies. Both interviewees are professionals in the

development aid business and have long experience in transforming knowledge from multiple sources into an overall strategy.

OLC step 3: Knowledge utilization

GIZ uses the knowledge gained of climate change to set up and advertise PPP projects on mitigation and adaptation to the private sector and public administration. In the case of the coffee supply network, GIZ is committed to offer a number of services such as a) 'capacity development and implementation' to focus on adaptation measures on the basis of regional climate change scenarios; b) 'policy advice' to political actors and the development of investment models for farmers; and c) 'knowledge management' to publish the reports on agricultural practices in a changing environment and facilitate exchange of information (GIZ 2013b). In particular, GIZ distinguishes between micro and macro level activities. At the micro level, GIZ is involved in PPP-projects and provides advice on local impacts and the development of technologies to help farmers adapt to climate change. Interviewee (E) calls this process "empowerment" and explained that it includes the development of adaptation solutions, but not their actual implementation. For example, GIZ invested 600,000 EUR in the 'Coffee & Climate' project over three years. At the macro level, GIZ uses its knowledge to influence the national programmes of Ministries for Environment and Agriculture and to bring forward tea and coffee programmes in Germany as well as in the producing countries (*antecedent culture/commitment*). In conclusion, both interviewees argued that they have built up enough competence to offer advisory services to farmers and governments and to critically assess alternative positions such as in the Tanzanian case of the "Coffee & Climate project". Some farmers and local governments believe that they can benefit from climate change as more areas were projected to be suitable for coffee production. However, GIZ expertise and leadership in the project challenged the existing knowledge base and provided some opposing views that overall production areas will diminish. More accurate and scientifically-based forecasts (e.g. from CIAT, NRI, etc…) are needed to change farmers' opinions and raise awareness of the need for adaptation (*antecedent competence*).

Both interviewees argued that GIZ takes a pioneering role in organising climate change-related projects that involve private partners and enable the utilization of GIZ's large knowledge base together with practitioner's experiences of supply chain adaptation. The IDH coffee programme is the only climate change adaptation project that GIZ is currently involved in and this represents a small expenditure relative to the budget available on climate change. However, the pioneering work of GIZ has resulted in a revision of other organisations' strategies on climate change giving them a much more prominent role. For example, the

International Coffee Organization, the European Coffee Federation, or even 4C have only recently begun to view climate change as a major theme and this is partly a result of the projects GIZ has carried out.

In summary, knowledge utilization at GIZ is assessed to be strong, but limited to an advisory role. Both interviewees showed a passion for the development of adaptation strategies to improve the living conditions of farmers (*personal vision*). They are convinced that GIZ's pioneering work in climate change-related projects has a real impact and that the organisation is able to take a leading role in PPP projects by influencing other bodies with different interests. In the case of the coffee business, GIZ as a public organisation acts as an information clearing house and advises the sector on adaptation strategies and implementation procedures (*leadership*). GIZ' efforts in the coffee sector could be intensified as human and financial capacities are still relatively small in comparison to the overall resources available to deal with climate change. As GIZ takes a supporting role in the coffee supply network without being directly involved in production, trade, and sales, the organisation lacks the means to directly implement its ideas throughout the network and so depends on the collaborative willingness of the core SN partners.

OLC step 4: Adaptation

GIZ is not directly involved in the implementation of any adaptation measures along the supply network. Concerning the farmers who are directly impacted by climate change, interviewee (E) stated that: *"we do not actually go down to the farmers. That has to be done by intermediaries; rather we draw up adaptation plans together with advisory organisations such as SMS in the case of Kenya, for example".* GIZ is able to contribute significantly to the development of adaptation activities, but is unable to directly up scale the implementation across the coffee supply network.

Analysis summary

GIZ as a non-profit organisation that is owned by the federal German government is not directly impacted by climate change, but needs to intensify its OLC to cope with the projected changes in coffee producing regions around the world. As shown in Table 9-5, GIZ is very strong in knowledge absorption and transformation about climate change as evidence for almost all antecedents was found. Even though the antecedents for knowledge utilization on climate change were also revealed, the third OLC step is rated to be strong (rather than very strong), as due to its advisory role, GIZ lacks the power and abilities to realise adaptation strategies for the supply network. The organisation is not directly involved in the physical

implementation of adaptation activities, but consults farmers and policy makers in co-operation with local implementing organisations on broader plans for adaptation.

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	**++**	**++**	**+**	**-**
Enabling antecedents	(6 out of possible 6) - Personal vision/values - Learning - Motivation - Development & Training - Culture/ Commitment - Leadership	(4 out of possible 5) - Team commitment - Leadership - Development & Training - Culture/ Commitment	(4 out of possible 5) - Personal vision - Culture/ commitment - Competence - Leadership	Only supporting role to implement adaptation projects at the farmers' level

Table 9-5: OLC performance of GIZ

9.6 CIAT

The International Centre for Tropical Agriculture (CIAT) is a research institute that aims to reduce hunger and poverty, to improve human health in the tropics, and to increase the eco-efficiency of agriculture. CIAT was formally established in 1967 by the Colombian government and the Rockefeller, Ford, and Kellogg Foundations. The centre has its headquarters near Cali, Colombia, with regional offices in Nairobi, Kenya, and Hanoi, Vietnam. Around 200 scientists work in Latin America and the Caribbean as well as in 29 countries in sub-Saharan Africa, and in 5 countries in Southeast Asia. This structure facilitates collaboration with hundreds of partners to conduct high quality research as no single organisation can address the entire field of tropical agriculture. CIAT research areas encompass technologies and methods to better enable farmers and smallholders to enhance eco-efficiency in agriculture for more competitive and sustainable production. CIAT works on agro-biodiversity, soils, and decision- and policy analysis cutting across all tropical crops and production environments.

CIAT is also one of the 15 members of the CGIAR Consortium. The 'Consultative Group on International Agriculture Research' (CGIAR) is a global partnership that unites organisations engaged in research on reducing rural poverty, increasing food security, improving human health and nutrition, and ensuring more sustainable management of natural resources. CIAT's work contributes to CGIAR research programmes that address the major agricultural challenges of our time. In particular, CIAT is the lead centre for the programme on Climate Change, Agriculture and Food Security (CCAFS), which helps smallholder farmers adapt to and mitigate the effects of rising temperatures and increasingly unpredictable rains (CIAT 2009).

Interviewee (G) works as a scientist for CIAT and is in charge for the climate change portfolio in Africa, Central America, and the Caribbean. Currently, he is deployed in Kenya.

Findings from the interview

Changing environment

CIAT, is not directly impacted by climate change as it has no physical production and distribution operations exposed to climate change. It's work is indirectly affected by changing climate conditions as they represent an expanding field of research. New opportunities have opened up for in-depth research on adaptation techniques for agricultural practices of commodities such as coffee, tea, and cocoa. Therefore, CIAT is likely to take a more important role within the coffee supply network in the future as more scientific expertise on the impacts of climate change is required.

OLC step 1: Knowledge absorption

The interviewee holds an MSc in Geography and a PhD in Tropical Agriculture. Supported by his academic background, he is convinced that climate change is occurring and that it is becoming a serious issue for the agricultural sector though he admits that scientific research and future projections are subject to large amounts of uncertainty. He nevertheless argued that this uncertainty should not be a reason for not starting to tackle the problem (*antecedent personal vision/values*). In line with this personal perception, the interviewee noticed that over a period of six or seven years, people have begun to become more aware of climate change as a result of the proliferation of projects on mitigation and adaptation around the world. Initially there was no systematic evidence or research on the impacts of climate change on agricultural practices. His motivation is to contribute to the expanding body of practitioner views and theory thus raising the awareness to all SN agents to climate change. He further argued that the implementation of adaptation activities will take years, which is the reason why all research should start now: *"all will be worse in 20 years and then it is too late, probably"* (*antecedent motivation*).

Interviewee (G) absorbed knowledge of the impacts of climate change directly from the farmers. He argued that *"if you talk to the farmers, they have been telling for a while that there have been issues with the climate and that this would impact on their yield, quality and pest and disease"* (interviewee G). He also has to familiarise himself with other scientific research, i.e. academic papers, project reports such as from partnering institutes, and other reports such as the IPCC report, for example. Accordingly, the interviewee is able to combine theory, from

scientific research, with direct on the ground experience of the impacts of a changing environment on agricultural practices (*antecedent learning*).

When it comes to the remaining three antecedents *development & training*, *culture/commitment*, and *leadership*, little direct evidence was found. Yet, the interviewee made clear that CIAT, as a research institute, is obviously committed to support its members financially and with other resources to create as much knowledge of climate change and the impacts on agricultural practices as possible. Moreover, all researchers aim to create new knowledge and therefore very frequently participate in workshops and conferences. In conclusion, researchers at CIAT are very strong in knowledge absorption of climate change and its relevance to the coffee sector. The de-centralised structure of the organisation helps it to carry out field research directly in the growing regions. As such, the scientists are the most advanced SN agents on the subject of climate change and its impacts on the coffee supply network.

OLC step 2: Knowledge transformation

Discussions within CIAT about individual research and findings are difficult as all researchers are deployed around the world. Information exchange and knowledge transformation therefore happens via the CIAT's web blog. *"So whenever somebody does something or publishes a paper, does an analysis or something relevant they would post it on the blog"* (interviewee G). This kind of communication is understood to be very efficient within the organisation. Besides the blog, face-to-face meetings at conferences and peer reviewing procedures are a valuable means of knowledge transformation for scientists. There is, however, no structured and regular method of disseminating information about climate change adaptation within CIAT (*antecedent team commitment*).

Investigating the remaining antecedents, no direct evidence was found of CAIT engaging in *goal setting*, *development & training*, and *culture/commitment*. However, similar to the first learning step, the organisational concept is very much based on research by individuals. The scientific outcomes are not primarily used to create a CIAT knowledge base, but rather directly for the projects that the researchers are involved with. CIAT members mainly communicate via the CIAT blog and otherwise transform knowledge like all other researchers via peer-reviewed paper, reports and conferences. Yet, a specific knowledge transformation process could not be identified within CIAT despite the fact that programme leaders (e.g. on 'Tropical Forages' and 'Bean', etc…) and theme leaders (e.g. on 'Climate Change', etc...) were appointed to structure and prioritise research funding and resources (*antecedent leadership*). Overall, CIAT's

knowledge transformation process is assessed to be strong. Although its researchers transform knowledge as part of their daily work, organisational structures could be improved to create an institutional knowledge base.

OLC step 3: Knowledge utilization

Interviewee (G) argued that most agents in partnering adaptation projects send representatives from the corporate social responsibility (CSR) department. However, these managers do not normally understand the science of climate change and the detailed impacts on the coffee sector. He concluded that only the certification of coffee[16] has become mainstream, but not the need for adaptation. In general, interviewee (G) is highly competent to contribute scientific knowledge to the coffee supply network. Since 2005 he has led a team at CIAT that has developed and implemented spatial analyses and supply chain tools for coffee and cocoa. These tools permit the spatial identification and prediction of product attributes; the control and management of product quality; information flow along the supply chain; and the quantification of the impact of climate change. As such, for over eight years, the interviewee has been incorporating the data on climate change into models of crop outputs, the local economy, and supply chains (*antecedent competence*).

CIAT is committed to transforming scientific information and knowledge into information, such as maps and charts that can be much easier understood by practitioners. As shown in Figure 9-1, different sources of data, such as from the latest IPCC report for example, were used to forecast the suitability of different global regions to grow Arabica coffee by 2050. The comparison with today's suitability shows an overall significant decline with the largest reduction in Latin America. In many regions, climate conditions are likely to become worse for Arabica than today. As the Arabica species accounts for ca. 70-80 per cent of global coffee production, these easy to read maps help other SN agents to better understand the risks associated with climate change. They also help to raise awareness that the often discussed 2°C temperature increase threshold is not useful for the discussions in the coffee sector as it is too highly aggregated both geographically and in terms of the climate conditions required by coffee plants.

[16] Coffee is certified by different sustainability standards such as 4C, Fairtrade, UTZ, and Rainforest Alliance. The organisations assess ecological and ethical agricultural practices against their established standards. Labels on the products verify to the end customer that the products comply with the respective standard.

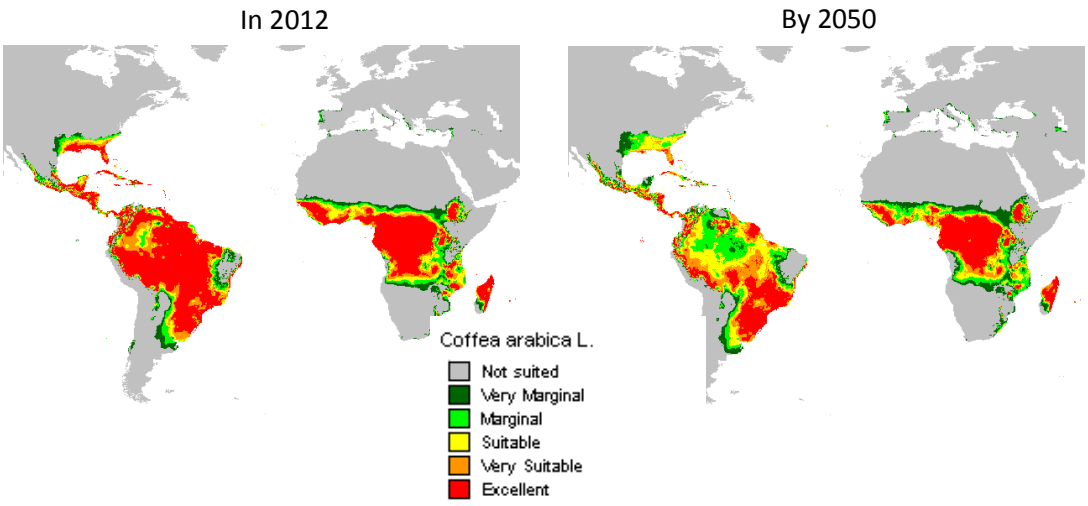


Figure 9-1: Comparison of suitability in growing Arabica coffee globally in 2012 and by 2050
Source: CIAT (2012)

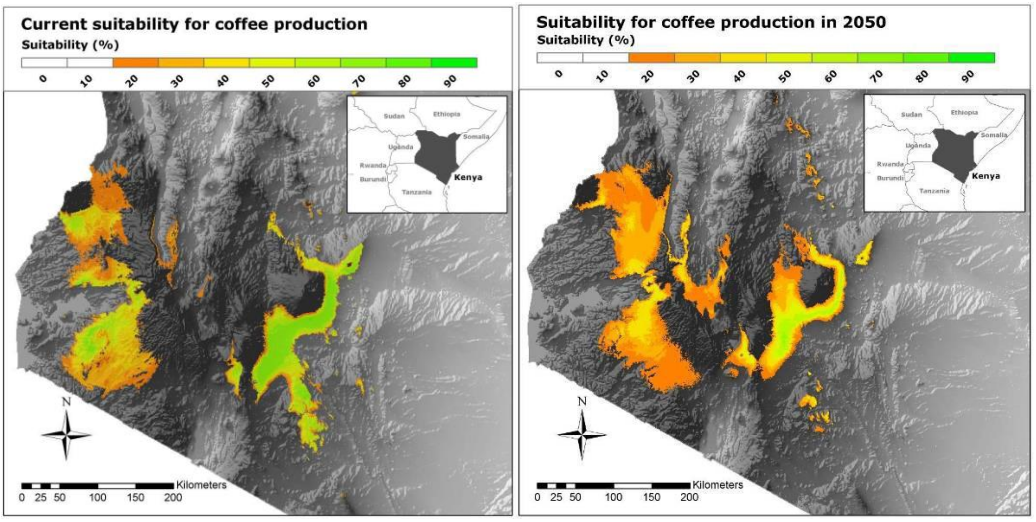


Figure 9-2: Comparison of suitability for coffee production in Kenya in 2012 and by 2050
Source: CIAT (2012)

On a more local level, CIAT also transforms highly complex IPCC data into more localised maps with a resolution of five or even one kilometre. In general, all maps are put on the CIAT homepage and are consequently made available to the public and to the entire coffee sector. As shown in Figure 9-2, climate change impacts on the suitability of areas for coffee production in the exemplified case of Kenya. Whereas the overall area for coffee growing is likely to increase by 2050, the projected suitability and yield is forecasted to fall significantly below today's performance. The overall production outcome in Kenya is likely to decline. In general, the maps produced by CIAT for all the different coffee regions provide a more user-friendly

version of the likely impacts allowing SN agents to run their analyses and think about localised adaptation strategies. In summary, CIAT forecasts that there will be less production per unit of area and also a decline in the quality of green coffee by 2050 globally. Overall, farmers at lower altitudes are much more vulnerable to climate change than farmers higher up because as temperature rises, farmers have to move up slope to compensate for the increase of temperature. Accordingly, regions that are rather flat with little opportunities to move to higher altitudes are highly vulnerable to climate change.

Besides these modelling activities, CIAT also uses its knowledge for providing advanced services such as field research, i.e. farmer surveys, interviews, and experimental projects with synthetic seeds and new agricultural practices. This may also include the testing of adaptation theories, models and concepts such as shade management and soil moisture under real conditions and with specific coffee varieties. CAIT can provide the scientific modelling, project management on the ground or both of these services (*antecedent commitment/culture*).

There was limited evidence of the *leadership* antecedent within the organisation as the researchers work mostly independently and do not require much supervision and guidance. However, the clear management structure with dedicated programme and theme leaders ensures that CIAT fulfils its role in developing eco-efficiency solutions to tackle smallholder poverty. CIAT also has the capability to lead the adaptation process by bringing together decision makers at national and regional level in order to steer financial support to the farmers. Interviewee (G) argued that *"we are only starting; we are only showing what is needed and what possibilities there are"*. Accordingly, all the developed adaptation strategies and toolboxes need to be tested in the field and often require a cost-benefit analysis to determine their impact on the farmer communities. CIAT prefers to be contracted for the entire analysis including the assisting role in the implementation process rather than being employed for just the consultancy work on knowledge creation.

In summary, CIAT is strong in knowledge utilization. The organisation is able to provide detailed projections about future climate conditions and therefore help the supply network to develop adaptation strategies. However, CIAT uses the created knowledge primarily to support other SN agents. For that reason, it depends on the willingness of its partners to employ CIAT for collaborative projects. Despite its high competence, CIAT only plays a supporting role in the coffee supply network raising awareness of the climate impacts.

OLC step 4: Adaptation

Considering the final OLC step, CIAT researchers take an advisory role, but do not carry out the implementation of adaptation measures as that has to be done by the farmers. However, CIAT develops the theory and tests the strategies in the field at a very limited local scale and in cooperation with the smallholders. Interviewee (G) argued that there are basically three different types of adaptation strategies. First, higher areas will become more suitable for coffee growing, as today these areas are just too cold. So the strategy is to grow coffee at higher altitudes even though that might be difficult as these areas are sometimes national parks, forests or preserved areas which should not be cultivated to start growing coffee. Second, some regions are likely to be affected by climate change and experience a decline in yields, but will remain able to grow coffee economically. Improved agricultural practices to enable adaptation such as shade, irrigation, soil fertility and moisture retention must be implemented soon to offset the climate trends projected over the next 10 to 30 years. Third, farmers at low altitudes are likely to suffer much earlier as they may become unable to grow coffee economically to the required standard. Consequently for them an appropriate adaptation strategy is to start diversifying and then switching to a different coffee species (e.g. Robusta coffee) or to a similar commodity such as cocoa, for example. When switching from Arabica to Robusta, the transformation process is risky and requires huge financial investment as the farmers get less money per quintal sold and ultimately need higher yields to compensate.

Analysis summary

In summary, CIAT is very strong in knowledge absorption as the purpose of the institute is to research the environment and the impacts of changes on agricultural practices. The scientists predominantly work directly in the regions and absorb not only knowledge from discussions with other researchers, but also from their projects with the farmers. Knowledge transformation is judged to be strong though not very strong, as the scientists employed by CIAT work on different projects in different regions, which makes it difficult to create an organisational knowledge base. Similarly, knowledge utilization is also assessed to be strong as CIAT's scientific work contributes significantly to the coffee sector. Yet, the organisation is dependent on the core SN agents to actually make an impact throughout the supply network. Finally, the implementation of the adaptation strategies is left to the farmers. Even though CIAT researchers assist in implementing the developed adaptation measures, they remain in a position in which they only advise the smallholders. As in the case of the other supporting SN agents, the last OLC step is therefore assessed to be weak. Table 9-6 summarises the findings.

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	**++**	**+**	**+**	**-**
Enabling antecedents	(5 out of possible 6) - Personal vision/values - Learning - Motivation - Development & Training - Culture/ Commitment	(2 out of possible 5) - Team commitment - Leadership	(4 out of possible 5) - Culture/ commitment - Competence - Leadership	Consultancy to implement adaptation projects at the farmers' level. Strong involvement at project scale

Table 9-6: OLC performance of CIAT

Having presented the findings from the interviews in detail for the exemplified 5 organisations, the analyses for the remaining 12 organisations are presented as summaries only. Initially, every company and interviewee is introduced and the agent's role within the coffee supply network is clarified. Then, the key findings are discussed and summarised in the well-known table format. The full analysis of the interviews as in the cases of the previously presented five agents can be found in the digital appendices (D to O), respectively.

9.7 Sustainable Management Services (SMS)

Sustainable Management Services (SMS) is part of the Ecom Coffee Group and has been established to create a company-wide, co-ordinated approach and platform for inter-company exchange. In 1999, Ecom started its first projects in Mexico and Central America to support small holder farmers in collaboration with other agents and NGOs. In the decade since, Ecom subsidiaries around the world have developed considerable in-house capabilities to train and support farmers that are nowadays streamlined through SMS. The mission of the SMS group is to improve the economic, social, environmental, and health conditions of coffee growers and their families. Its global strategy is fundamentally driven by empowered, accountable teams at origin, and fully aligned to the business needs. In particular, the 'Ecom Coffee Group' currently has farmer training and development programmes in every region of its origin operations, i.e. in Central America, Africa, and Asia. Interviewee (H) works as 'Project Supervisor' and has been with SMS in Kenya since 2007.

Analysis summary

As shown in Table 9-7, SMS is very strong in absorbing knowledge of climate change, but remains weak in the subsequent two OLC steps. Particularly by experiencing the impacts of climate change directly on the farms, SMS is able to obtain first-hand information about the consequences of a changing environment for coffee production. When it comes to knowledge transformation and utilization, SMS clearly has some capabilities, but strongly relies on the co-operation with its parent company Ecom. Therefore, SMS as an independent organisation is assessed to be weak in OLC steps two and three. The final learning step is assessed to be strong, even though SMS is not directly responsible for the implementation of the adaptation measures at the farm level. However, the long-term and close relationships with the small-holders bring SMS into a position to actively influence and facilitate adaptation much more effectively than standard organisations, for example. SMS agronomists and other staff are highly qualified and experienced in working with farmers and have a strong impact on the rate of improvement in good agricultural practices.

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	**++**	**-**	**-**	**+**
Enabling antecedents	(4 out of possible 6) - Personal vision/values - Learning - Motivation - Culture/ Commitment	(1 out of possible 5) - Culture/ Commitment	(3 out of possible 5) - Personal vision - Culture/ commitment - Competence	Strong technical support and advisory role to implement adaptation projects at the farm level. Close working relationship and influence on the smallholders

Table 9-7: OLC performance of SMS

9.8 Tchibo

Tchibo is Germany's largest coffee roaster and amongst the ten largest coffee roasters worldwide. It was founded in 1949 by Max Herz and since then has remained privately owned. The family business has evolved into an international company and operates in many more business sectors than the traditional selling of coffee. Over the years, Tchibo has systematically expanded its range to non-food products that today represent more than half of the 3.5 billion euro turnover business. Today, approximately 12,000 employees work for Tchibo, including 8,300 in Germany (Tchibo 2013). Interviewee (I) has been with Tchibo for eleven years and today works as 'Category Leader' in the field of corporate responsibility at the strategic level.

Interviewee (J) is 'Senior Manager Corporate Responsibility' at Tchibo and particularly responsible for the coffee sector. She is the field expert and Tchibo's link to the operational area.

Analysis summary

Tchibo is very strong in knowledge absorption, transformation, and utilization. Strong organisational commitment and clear leadership qualities combined with strong personal interest and competences of the assigned senior management enable the company to create a very good knowledge base on climate change and the impacts for the coffee business. Despite the fact, that Tchibo is a large player in the market it lacks financial resources and manpower to make its supply network adaptive to climate change without external support. For that reason, knowledge is used to form a collaborative and sector-wide approach to help farmers improving their agricultural practices and actually have an impact on the multi-million small-holder coffee supply base. Although Tchibo is not primarily involved in the implementation phase at the farm level, it supports farmers financially. It can be argued that relative to the company's turnover, Tchibo makes the highest investment in adaptation projects, plantlet buying, and technical services at the farm level amongst the investigated organisations. For that reason, the organisation has a much greater impact on adaptation than standard organisations, for example, and is therefore assessed to be strong in the final OLC step (see Table 9-8).

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	**++**	**++**	**++**	**+**
Enabling antecedents	<u>(6 out of possible 6)</u> - Personal vision/values - Learning - Motivation - Development & Training - Culture/ Commitment - Leadership	<u>(4 out of possible 5)</u> - Team commitment - Leadership - Development & Training - Culture/ Commitment	<u>(4 out of possible 5)</u> - Personal vision - Culture/ commitment - Competence - Leadership	Activities are beyond an advisory role. Invests the highest amount of money into adaptation measures relative to turnover

Table 9-8: OLC performance of Tchibo

9.9 Nestlé

Nestlé is the world's leading nutrition, health and wellness company with its headquarters in Vevey and Cham in Switzerland. In 2012, the company turned over 62 billion Euros with its

diversified range of products including the coffee division with its key brand Nestcafé. Accordingly, Nestlé is one of the biggest roasters in the coffee supply network. Interviewee (K), has worked as independent sustainability advisor to the Executive Vice President of Operations at Nestlé for two and a half years with the aim of co-ordinating sustainability issues in commodity supply chains, manufacturing, and logistics. The scope included a wide range of topics on responsible sourcing, community impacts and rural development and also specifically climate change adaptation. The role involved both external engagement and internal capacity building. Today interviewee (K) works with Nestlé on a permanent basis. The role is an evolution of the previous advisory role to support the operations teams in finding solutions to improve the sustainability performance of the company and approaches to create shared value. A key aspect is to maintain and enhance working relationships and partnerships with outside stakeholders. Internally, the role supports the operations teams (agriculture, commodity supply chains, engineering & manufacturing) and ensures alignment with R&D and marketing. The focus is also particularly on rural development, natural capital, deforestation and water.

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	**++**	**++**	**++**	**+**
Enabling antecedents	(6 out of possible 6) - Personal vision/values - Learning - Motivation - Development & Training - Culture/ Commitment - Leadership	(5 out of possible 5) - Team commitment - Goal setting - Leadership - Development & Training - Culture/ Commitment	(4 out of possible 5) - Personal vision - Culture/ commitment - Competence - Leadership	Activities are beyond an advisory role. Supply of 200 mio plantlets and investment of CHF 500 mio in total by 2020

Table 9-9: OLC performance of Nestlé

Analysis summary

Nestlé has excellent organisational learning abilities as summarised in Table 9-9. The organisation is very strong in the first three OLC steps as evidence for almost every antecedent is found. Being a listed company necessitates a focus on sustainability and climate-related activities and due to the fact that Nestlé is a large player in the coffee business with extensive financial resources, it is reasonable to conclude that Nestlé takes a leading role in making the supply network more resilient to climate change. The company procures a significant amount of green coffee directly in the producing countries and therefore has a strong interest to assist

in good agricultural practices to sustain continuous supply and to conform to the corporate sustainability programme. Despite Nestlé's financial contribution and direct deliveries of plantlets to the farmers, the final OLC step is rated strong and not very strong as the company's contribution is limited to selected adaptation activities. However, the Nestlé support in the countries is much stronger in comparison to other investigated SN agents. That might be due to the company size and available resources as well as due to the direct dependency on the raw product.

9.10 Paulig

Gustav Paulig Ltd belongs to the Paulig Group and is based in Helsinki, Finland. The company was founded in 1876 and is family-owned. Gustav Paulig Ltd engages in high-quality coffee production as well as sales of coffee and hot chocolate products. With a focus on the North-Eastern countries of Europe, the company is the market leader in Finland and the Baltic region. It also has a strong position on the Russian roasted coffee market (Coffee & Climate 2013). Today, ca. 500 employees work for the coffee division which turns over ca. 360 million Euros per annum. In total, the medium-sized coffee roaster with a clear regional target market purchases ca. 0.7 per cent of the coffee production worldwide. Due to its relatively small size, Paulig does not procure directly from the producing countries, but buys its coffee from global traders such as Neumann and Ecom. Interviewee (L) currently holds the position of 'Corporate Responsibility Manager'.

Four OLC steps	5. Knowledge absorption	6. Knowledge transformation	7. Knowledge Utilization	8. Adaptation
Evaluation	-	-	-	--
Enabling antecedents	(3 out of possible 6) - Personal vision/values - Learning - Motivation	(2 out of possible 5) - Team commitment - Culture/ Commitment	(1 out of possible 5) - Culture/ competence	Virtually no activity in the implementation of adaptation strategies

Table 9-10: OLC performance of Paulig

Analysis summary

The overall organisational learning performance of Paulig is weak as summarised in Table 9-10. The organisation is not even strong in a single OLC step and is not involved in adaptation activities at all. Even though it had appointed a manager that deals with climate related topics, much of Paulig's activities refer to carbon cutting and energy efficiency. There is clear lack of understanding of the impact of climate change on the coffee sector, and there were no

knowledge and resources developed to tackle the climate problem. Rather, Paulig' strategy relies on inter-organisational projects (such as Coffee & Climate, for example) to preferably absorb knowledge and to create its own company knowledge base. In summary, Paulig is not directly impacted by climate change and does not directly purchase from the farmers. In combination with its relatively small size, the organisation has not been focusing strongly on adaptation to climate change and is therefore weak in all four OLC steps.

9.11 Ecom Trading

With over 150 years of market experience, Ecom Agroindustrial Corp. Ltd is a global commodity trading and processing company specializing in coffee, cotton, and cocoa. It is the 2nd largest coffee trader and miller in the world with operations in 18 major producing and consuming countries. In 2011, the company turned over 4 billion USD and handled approximately 11 million bags of coffee. Since 1935, when Ecom opened its first coffee office in São Paulo, Brazil, the company has expanded its partnerships across five continents to maintaining operations directly and in close collaboration with farmers and other business partners. Over time, Ecom has therefore transformed from a pure trading organisation to an integrated company offering services such as buying from producers at origin, providing primary processing of raw materials to prepare the product for export directly in the countries of origin, logistics and risk management, and selling to the branded product manufacturers**.** Beyond these primary activities, Ecom also provides training and on the ground services directly to the farmers as well as support in financing production and sustainability certification. This approach allows the company to act as intermediary and partnering stakeholder throughout the supply network and helps to create environmental training of the local communities for a sustainable industry (Ecom 2013b; 2011). Interviewee (M) works as the group's sustainability advisor, i.e. he oversees and co-ordinates all sustainability efforts and as senior manager takes responsibility for the relationships with other SN stakeholder in this business field.

Analysis summary

Ecom is weak in understanding climate change. Despite the core trading function in the supply network, the organisation has not developed strong knowledge absorption and transformation capabilities. There are no formal training sessions to increase the knowledge base and there are relatively weak organisational structures and processes in place to scale up individually held knowledge to the corporate level. Considering the third OLC step, Ecom is strong in knowledge utilisation and identified the financial burden for the farmers as one of the biggest challenges for supply network adaptation. Ecom is committed to contribute to the sector-wide

initiative for supply chain adaptation, but is rather reluctant as it views adaptation mainly as a competitive factor. For this reason, Ecom adopts an almost follower position and aims to see a specific return prior to large investments in adaptation projects. The final OLC step is also rather weak as Ecom only sends out agronomists via its subsidiary SMS to help farmers implement good agricultural practices. In conclusion, Ecom recognises the trade-off between adaptation activities that are preferably Ecom steered for competitive reasons, and the extremely small impact on the entire supply network such Ecom driven initiatives will have. Taking into account both sides, Ecom is willing to collaborate with other SN agents for a mutual adaptation benefit, but wants to have clear action rules established prior to any projects and also avoids pioneering and financing projects for the benefits of market rivals (see Table 9-11).

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	**-**	**-**	**+**	**-**
Enabling antecedents	(3 out of possible 6) - Personal vision/values - Learning - Leadership	(2 out of possible 5) - Leadership - Culture/ Commitment	(3 out of possible 5) - Motivation - Culture/ commitment - Leadership	Only consultancy to implement adaptation projects at the farmers' level/external to the own company

Table 9-11: OLC performance of Ecom Trading

9.12 Armajaro Trading

Armajaro Trading is a global soft commodity trading house and supply chain manager founded in 1998. Today, it is one of the world's largest traders in soft commodities. The organisation has it's headquarters in London and trades all major crops such as cocoa, coffee, sugar, and more recently also cotton. Worldwide, ca. 2,000 employees work for the company. Besides the core trading function, Armajaro also offers financial instruments such as forward price cover and value-added services from the initial sourcing and pricing through to the factory gate. Armajaro's supply chain function includes the aggregation of smallholder communities to create specific supply chains for selected roasters with a clear focus on traceability and sustainability. Interviewee (N) is 'Manager for Agriculture and Project Planning' and the person who reports to top management on any climate-related activities in the coffee business.

Analysis summary

The learning performance of Armajaro is weak throughout all four OLC steps as shown in Table 9-12. Despite its strong market position in the coffee trade, the organisation lacks clear structures and leadership for knowledge absorption and transformation. Despite appointing a senior manager responsible for sustainability issues, the company has hardly any competence regarding climate change adaptation issues. Instead, it focuses on mitigation activities and aims to improve smallholder livelihoods even though this might be to the disadvantage of the coffee business particularly as one solution proposed is crop diversification. As part of the utilization step, the interviewee mentioned a number of activities at farm level, such as financial support and assistance in improving agricultural practices. Yet, the company has not been developing any adaptation measures as it lacks competence and clear guidance from top management. The interview revealed that the company is averse to collaborating closely with others due to competitive reasons and is therefore only at the initial stage of responding to the problem of climate change. They have also weak capabilities in the final adaptation step. On the one hand, the company assists farmers in their own projects to improve their agricultural practices. On the other hand, adaptation of the existing pricing structures, which are within the scope of the organisation, and would enable the financing of adaptation measures at farm level, are not being pursued.

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	-	-	-	-
Enabling antecedents	(1 out of possible 6) - Learning	(2 out of possible 5) - Leadership - Culture/ commitment	(2 out of possible 5) - Culture/ commitment - Leadership	Only little efforts to adapt the pricing system. Currently unable to finance adaptation activites

Table 9-12: OLC performance of Armajaro

9.13 Gollücke & Rothfos

Gollücke & Rothfos was founded by the families Rothfos and Gollücke in Bremen, Germany in 1922. In 1925, Rothfos established its own company in Hamburg and sold his old shares to the Gollücke family, thus establishing two separate businesses. The newly founded Rothfos organisation later became part of the Ecom group, and the Bremen based Gollücke & Rothofs

company was sold to the Volcafe group. The head office of Volcafe's coffee division is located in Winterthur, Switzerland and operates branches in 14 of the top 20 coffee growing regions worldwide with sales offices in all the major consuming regions. In 2004, Volcafe was taken over by the London based ED&E Man group one of the leading coffee merchants in the world. The Group has 3,400 people in around 60 countries and specialises in trading sugar and coffee. In terms of Gollücke & Rothfos and Volcafe, they procure their coffee directly and exclusively in the growing countries and are not involved in the buying of coffee for trading on commodity markets. Rather, the organisation processes and sells the purchased coffee directly to the roasters. Interviewee (O) is 'Managing Director' of Gollücke & Rothfos and is also 'Member of the Board of Directors' of Volcafe. The entire group is privately owned and not a public organisation. The interviewee is also executive partner of Volcafe.

Analysis summary

The trading company Gollücke & Rothfos is weak overall in learning about climate change (see Table 9-13). Despites its strong link to the corporate level of Volcafe, the interview revealed little knowledge of the precise impacts of climate change and shows only a general understanding of how farmers suffer from climate change. Even though the company appointed a central manager for corporate social responsibility, climate change is not specifically addressed. There is no evidence of any internal platform to share knowledge of climate change. The utilization of any created knowledge refers to CSR projects and planning. In the first three OLC steps, the organisation is weak and consequently the final adaptation step is assessed to be very weak. There was no example identified in which Gollücke & Rothfos was involved in the implementation of any developed adaptation measures.

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	-	-	-	--
Enabling antecedents	(1 out of possible 6) - Learning	(1 out of possible 5) - Culture/ Commitment	(1 out of possible 5) - Culture/ competence	No activity related to the implementation of adaptation strategies at all

Table 9-13: OLC performance of Gollücke & Rothfos

9.14 Fairtrade

Fairtrade International (FLO) is a multi stakeholder body that is responsible for the strategic direction of Fairtrade, sets Fairtrade standards and supports producers. It offers an alternative

approach to conventional trade and is based on a partnership between producers and consumers allowing them to improve their lives and plans for their future. When a product carries the FAIRTRADE Mark it means the producers and traders have met Fairtrade Standards. The Standards are designed to address the imbalance of power in trading relationships, unstable markets and the injustices of conventional trade. Most products have a Fairtrade Price, which is the minimum that must be paid to the producers. In addition producers get an additional sum, the Fairtrade Premium, to invest in their communities.

Besides FLO with its 80 staff, four further sub-units are part of the Fairtrade body: FLO-CERT; Fairtrade labelling initiatives; Fairtrade producer networks; and Fairtrade marketing organisations. Most importantly is the sub-unit FLO-CERT which is an independent certification company that inspects producers and traders to ensure they comply with Fairtrade standards. Today, there are now 827 Fairtrade certified producer organisations in 58 producing countries, representing over 1.2 million farmers and workers. Approximately 52 million Euros were distributed to communities in 2009 for use in community development. Including families and dependents, Fairtrade International estimates that six million people directly benefit from Fairtrade. Interviewee (P) is “Policy Manager, Climate Change and Sustainable Development” at FLO and has been working for Oxfam before he joined Fairtrade two years ago. He is deployed to the strategy and policy unit at FLO and co-ordinates all activities on climate change and sustainable development.

Analysis summary

The assessment of Fairtrade’s learning abilities revealed that the organisation is strong in knowledge absorption, transformation, and utilization, but like other supporting SN agents remains weak in the final OLC phase ‘adaptation’ (see Table 9-14). Despite the fact that Fairtrade has only recently begun to integrate supply chain adaptation to climate change into its business, the organisation made good progress by appointing a responsible manager who absorbs knowledge, co-ordinates the internal flow of information, and contributes to the development of Fairtrade’s strategy on adaptation. At the senior level, the organisation has excellent competences as producer organisations haves seats on the Board that makes the final decision on climate related projects. The organisation has developed an adaptation strategy that comprises four selected components. As part of the component ‘awareness and advocacy’, the fair adaptation climate module was created to investigate farmers’ needs and to provide approaches that improve agricultural practices in response to a changing environment. Fairtrade’s resources are, nevertheless, limited and the interviewee clearly argued that knowledge creation processes within the organisation could be improved through

a better integration of different departments and less rivalry amongst different key themes for financial resources. There is little interaction between the sub-units, and workshops for training purposes on climate change have been held only occasionally. Like other supporting SN agents, the final OLC step 'adaptation' is not carried out by the organisation; Fairtrade only assists external partners to adapt to climate change.

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	**+**	**+**	**+**	**-**
Enabling antecedents	(4 out of possible 6) - Personal vision/values - Learning - Culture/ Commitment - Leadership	(3 out of possible 5) - Team commitment - Leadership - Culture/ Commitment	(3 out of possible 5) - Competence - Culture/ commitment - Leadership	Only consultancy to implement adaptation projects at the farmers' level/external to the own company

Table 9-14: OLC performance of Fairtrade

9.15 Rainforest Alliance

Rainforest Alliance (RA) is a organisation that works to conserve biodiversity and ensures sustainable livelihoods by transforming land-use practices, business practices and consumer behaviour. The organisation was established in 1987 and has about 300 employees in 20 global offices who work in different areas such as timber extraction, agricultural expansion, cattle ranch lands, and tourism that are understood as major drivers for environmental destruction. RA aims to ensure that farmers and companies meet rigorous sustainability standards that can be identified by the Rainforest Alliance Certified™ seal and Rainforest Alliance Verified™ mark. On Rainforest Alliance Certified™ farms, farmers are prohibited from deforesting their land. They must also maintain healthy soils, protect native ecosystems and decrease their use of energy, water and agrochemicals, thereby reducing GHG emissions and increasing the levels of carbon stored in vegetation on their farms. With a particular focus on climate change, RA and its partners help communities and businesses to conserve forests, plant new trees, earn sustainable livelihoods and adapt to changing climate conditions through training, certification, and verification. Moreover, RA provides forest managers, farmers and tourism-business owners with tools to conserve their resources and to ensure that they are complying with rigorous environmental, social and economic standards (Rainforest Alliance 2013). Interviewee (Q) is the 'Director of the Climate Programme' at RA and has been working on climate change-related themes since 2005. His responsibilities include the leadership from the headquarters in

Washington, D.C. U.S., and the organisation of all global efforts that address mitigation and adaptation activities with a particular focus on forestry and agricultural landscapes in the tropics and sub-tropics. Therefore, the interviewee is particularly drawn to supply networks for major commodity crops that are favoured for RA certification such as coffee, cocoa, and tea, for example.

Analysis summary

Rainforest Alliance is very strong in the 'understanding' part of the OLC and has developed very strong abilities in knowledge absorption and transformation (see Table 9-15). The organisational commitment to help farmers become more adaptable to climate change has resulted in adapted structures. These include a dedicated team with a senior manager in the headquarters, and decentralised specialists on environmental changes who work directly with farmers and provide feedback to the organisation on climate change impacts. A web-based platform, regular training, and clear leadership facilitate the creation of RA's detailed knowledge base dealing with the impacts of climate change on the global production of agricultural goods. RA is also able to develop and communicate adaptation strategies for the supply network and particularly for the farmers. However, the organisation only takes a supporting role in the supply network without being directly involved in the production and trading processes. Therefore, RA uses its own knowledge to propose adaptation strategies, but firstly needs to align its efforts with other actors to have an impact on the core agents. Secondly, it also requires external knowledge from other stakeholders with more localised knowledge to revise and improve the initially developed strategies. The final adaptation step is evaluated weak as RA only adopts an advisory role. Despite the fact that RA staff are in the field, the organisation does not actually implement any strategies and only supports the training of local communities to scale up adaptation throughout the farmer supply base.

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	**++**	**++**	**+**	**-**
Enabling antecedent	(6 out of possible 6) - Personal vision/values - Learning - Motivation - Development & Training - Culture/ Commitment - Leadership	(4 out of possible 5) - Team commitment - Leadership - Development & Training - Culture/ Commitment	(4 out of possible 5) - Personal vision - Competence - Culture/ commitment - Leadership	Only advisory role to imple-ment adaptation projects at the farmers' level/ external to the own company

Table 9-15: OLC performance of Rainforest Alliance

9.16 UTZ

UTZ Certified stands for sustainable farming and better opportunities for farmers, their families and the planet. The organisation was founded in the 1990s by the Belgian-Guatemalan coffee grower, Nick Bocklandt, and a Dutch coffee roaster, Ward de Groote in order to address the limitations of the coffee market and consumer labels (certifications) available at that time. Together, they initiated the UTZ programme to look after the farmers and the environment and to implement 'sustainable quality' on a large scale in the worldwide market. The first local office was opened in Guatemala City in 1999, and the head office opened in Amsterdam in 2002. Today, ca. 90 employees work for UTZ globally. The UTZ programme enables farmers to learn better farming methods, improve working conditions and take better care of their children and the environment. Through the UTZ programme farmers may grow better crops, generate more income and create better opportunities while safeguarding the environment and securing the earth's natural resources. Accordingly, an increasing share of the world's coffee, cocoa and tea is grown responsibly and UTZ certified. UTZ is not a membership organisation, but a foundation with an annual budget of about six million Euros, 30 per cent of which is funded through grants and 70 per cent by contribution from the private sector. The private sector pays in two forms into the system: an annual fee and each time they use an UTZ logo to label their products (UTZ 2013). Interviewee (R) works as 'Partnership Development Manager' and Interviewee (S) as 'Field Development Coordinator Latin America' with UTZ.

Analysis summary

UTZ is very strong in knowledge absorption. Both interviewees made clear that the organisation started a little later than the competition and therefore they are highly motivated to learn and lead in the first OLC step. However, the company remains weak in the subsequent OLC steps as summarised in Table 9-16. UTZ has been unable to transform the individually gained knowledge into a corporate strategy for adaptation and is consequently weak in using its little knowledge base to have an impact on the coffee sector. UTZ currently focuses on structuring its climate change-related activities by contracting external expertise. The aim is to achieve a position whereby UTZ initiates ideas and possibilities for adaptation, and co-operates closely with the private sector that has to take the lead in the adaptation process.

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	++	-	-	-
Enabling antecedents	(6 out of possible 6) - Personal vision/values - Learning - Motivation - Development & Training - Culture/ Commitment - Leadership	(2 out of possible 5) - Development & Training - Culture/ Commitment	(1 out of possible 5) - Leadership	Only consul-tancy to implement adaptation projects at the farmers' level/external to the own company

Table 9-16: OLC performance of UTZ

9.17 Neumann foundation

The Neumann Coffee Group (NKG) is the world's largest trader and service provider for green coffee. As part of this group, the Neumann foundation was established in 2005 to develop and extend the activities of the Neumann Group's consulting firm 'Embden Drishaus & Epping Consulting' (EDE). This consulting subsidiary was established in 1991 and had the task of making the know-how of the Neumann Group available to the production sites in the different producer countries. Yet, the consulting structure mainly helped private agents in the coffee supply network to become more competitive and was not suited to collaborative work with other coffee stakeholders. For that reason, the foundation structure is a much more transparent platform to bring together diverse players from the private and public sector as it is a non-profit making organisation. Accordingly, the foundation acts as an umbrella organisation for non-competitive projects and uses the Group's consulting firm EDE to carry out the field work in the producing countries. In total, the foundation and EDE have eight offices globally (United States, United Kingdom, Guatemala, Brazil, Ivory Coast, Tanzania, Uganda, and Vietnam) and smaller teams of its own staff that operate around the world outside these eight areas. Overall, ca. 50 employees together with a further 50 people who are temporarily sub-contracted work for the foundation and EDE in 23 projects reach 80,000 farmers directly. The main purpose of the foundation (capital of 10 million Euros) is the promotion of sustainability in tropical agriculture, i.e. 'environmental production' and 'farmer empowerment' by ensuring that sustainability is regarded as highly topical and important; and by adding value to the smallholder producer supply base. Interviewee (T) is 'Managing Director' of the Neumann foundation.

-

Analysis summary

The analysis of the Neumann foundation revealed very strong capabilities in the knowledge absorption step. The organisations is in very close contact with research institutes and farmers around the world to better understand the impacts of climate change and to receive information concerning any climate-related projects in the sectors. In the subsequent steps 'knowledge transformation' and 'knowledge utilization, the Neumann foundation has developed strong capabilities. In particular, the interviewee is the lead-coordinator in both steps and ensures an organisational commitment to share knowledge internally and externally with project partners. The foundation aims to train its staff in frequent workshops, often together with other supporting SN agents such as the standard organisations. The knowledge base created is then used to develop adaptation measures that help farmers to improve their agricultural practices and ultimately their livelihoods. However, as in any other case of supporting agents, the implementation of adaptation measures remains the responsibility of the farmers. Even though the foundation takes the role of a consultancy to assist and supervise in the adaptation process, the organisation is weak in the final OLC step as any activity is for the purpose of partners in the supply network (see Table 9-17)

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	**++**	**+**	**+**	**-**
Enabling antecedents	(4 out of possible 6) - Personal vision/values - Learning - Culture/ Commitment - Leadership	(3 out of possible 5) - Goal setting - Development & Training - Culture/Commitment	(3 out of possible 5) - Personal vision - Culture/ Commitment - Leadership	Only consultancy to implement adaptation projects at the farmers' level/external to the own company.

Table 9-17: OLC performance of Neumann foundation

9.18 National Research Institute (NRI)

The Natural Research Institute (NRI) is a specialised Institute and School of the University of Greenwich. Its past work focused much on developing countries, but it has increasingly attracted attention by managers involved in the extraction of natural resources in

industrialised countries particularly in tropical and sub-tropical zones. The interviewee (U)[17] is 'Head of the Department of Agriculture and Environment' and leads a team of ca. 20 researchers with different specialities. He is an agroecologist with 20 years of experience in research and capacity building on sustainable design and management of tropical agroecosystems in Central America and Mexico. Particularly, his research has focused on the evaluation of ecosystem services, tree crop interactions, agroecology of shaded coffee, participatory design and management of agroforestry systems and socioeconomic impacts of sustainable value chains.

Four OLC steps	1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Evaluation	**++**	**-**	**+**	**-**
Enabling antecedents	(6 out of possible 6) - Personal vision/values - Learning - Motivation - Development & Training - Culture/ commitment - Leadership	(2 out of possible 5) - Leadership - Culture/ commitment	(3 out of possible 5) - Motivation - Culture/ Commitment - Competence	Only consul-tancy to implement adaptation projects at the farmers level/external to the own organisation

Table 9-18: OLC performance of NRI

Analysis summary

The interviewee is very strong in knowledge absorption and has a strong commitment to use his expertise to contribute to the development of adaptation measures. As a researcher with more than 20 years of experience in natural resources in the tropics and subtopics, he has acquired extensive knowledge of climate-related and agricultural themes and has also carried out a number of projects specific to the coffee business. However, like CIAT, much research is personalised and there has been little knowledge transformation within the Institute about adaptation of the coffee supply network to climate change. Therefore the second OLC step is assessed to be weak. Much stronger is the utilisation of the created knowledge as the interviewee is keen to develop adaptation strategies to improve agricultural practices at the farm level. He presents his findings in scientific journals, blogs, and project reports and also discusses his research with other supply network agents in round tables and at conferences.

[17] Even though the interviewee was not permanently employed with NRI during all the time in which inter-organisational projects took place, NRI is used as reference in the thesis for consistency reasons.

The emphasis is on translating the scientific knowledge into a more practitioner friendly language and on mapping the future climate projections for coffee growing regions. Yet, every attempt to use the created knowledge is for the purpose of other organisations as NRI is not directly impacted by climate change. Therefore, the third step is evaluated strongly. Finally, the implementation of adaptation measures is not part of NRI's work. The researcher rather assists in the development and consults farmers on good agricultural practices upon request. As the final OLC step is only carried out if NRI is subcontracted and never exceeds the level of consultancy, adaptation is assessed to be weak. Table 9-18 summarises the findings.

9.19 Summary of organisational learning

The investigation of the 17 core and supporting agents in the coffee supply network revealed that all organisations lack very strong competences in all four OLC steps. Except for the two large roasters investigated, which have at least strong capabilities in each OLC step, the remaining agents are very strong or strong in certain steps, but not throughout the entire organisational learning cycle.

Type of agent	*SN Agents*	*Four Phases of the Organisational Learning Cycle*			
		1. Knowledge absorption	*2. Knowledge transformation*	*3. Knowledge Utilization*	*4. Adaptation*
Farmers	Julio Alfaro	++	-	-	++
	SMS*	++	-	-	+
Roasters	Cafédirect	++	++	+	-
	Tchibo	++	++	++	+
	Nestlé	++	++	++	+
	Paulig	-	-	-	--
Traders	Ecom Trading	-	-	+	-
	Armajaro Trading	-	-	-	-
	Gollücke & Rothfos	-	-	-	--
Standards	4C Association	-	-	-	--
	Fairtrade	+	+	+	-
	Rainforest Alliance	++	++	+	-
	UTZ certified	++	-	-	-
Implementers	GIZ	++	++	+	-
	Neumann foundation	++	+	+	-
Scientists	CIAT	++	-	+	-
	NRI	++	-	+	-

*Classified to farm level due to its very close working relationship; interviewee is qualified to also represent the farmers' perspective.

Table 9-19: Overview of organisational learning of the investigated SN agents

On the basis of the case study data an assessment has been made of the strengths of the core and supporting agents in the organisational learning process. Each agent category is assessed as follows:

Farmers

The interviewed organisations experienced the impacts of climate change in the form of extreme weather and increases in cherry and coffee tree diseases. They are very strong in knowledge absorption and are also committed to implement the responding adaptation measures. However, despite the fact that the smallholder farmers are the most exposed agents to climate change throughout the supply network, they are weak and unable to create a proper knowledge base and to develop adaptation measures independently from other agents. Accordingly, coffee farmers need to adapt to climate change, but do not learn appropriately about climate change and are therefore unable to mitigate their exposure to the impacts of climate change. It can reasonably be concluded that farmers require external support from other organisations to learn and eventually adapt their plantations.

Roasters

The investigation of the roasters showed that they are very strong in the first three OLC steps and strong in the adaptation part. They are the most advanced in organisational learning and to some extent complete the OLC as they have much resource and financial power compared to others. However, the assessment of the adaptation step is primarily relative to the other organisations and does not give an absolute measure of the ability to adapt the entire organisation to the impacts of climate change. The roasters realised that they will be indirectly impacted by the decline in the quality and quantity of green coffee as a result of changing climate conditions. Therefore, they have begun to work directly with the farmers and invested a significant amount of resources and money to collaborate with farmers and implement the recommended adaptation measures. However, the assistance at the farmer level is very limited and mainly project based. For that reason, the roasters are strong in adaptation as they have already been involved in this step, but address only a tiny part of the global smallholder farmer community. As their efforts will not be enough to adapt their business to the climate impacts, it can be concluded that the roasters learn, but only little due to the limitations in the final OLC step.

Traders

The investigation of the traders in the coffee supply network clearly showed that they are weak overall in organisational learning. Despite their important function in the processing of

coffee from the original raw material producers to the roasters, they have developed little competence in knowledge absorption, transformation, and utilization. They clearly lack commitment and structures to better understand the impacts of climate change and have not set any priorities to develop adaptation measures in response. The traders face strong competition and are not willing to invest into a problem that is recognised, but not tangible enough to require for organisational learning at this stage. Although, the traders are one tier down the supply chain from the farmers, they are very little engaged in adaptation, despite the fact that they are also indirectly impacted by a changing climate. However, whereas the traders generally were identified to be weak in adaptation, Armajaro and Ecom have set up extension services that assist farmers in the implementation of adaptation measures directly in the fields. But these organisations such as SMS, for example, often work independently from the traders' headquarters and therefore have little interaction in knowledge transformation and utilization.

Standard organisations

The investigation of the standard organisations showed a two sided picture. On the one hand, organisations such as Rainforest Alliance and Fairtrade are more advanced in organisational learning about climate change than 4C and UTZ. The former two are strong or even very strong in OLC steps 1 to 3 and have created structures and processes to better understand climate risk. In their role as supporting supply network agents, they have begun to realise the likely impacts on the farmers and started to develop analysis and adaptation tools that can be integrated into their existing certification schemes. However, climate change is only one topic to be addressed and as profit-making organisations that are dependent on their customer to purchase their certified coffee, they are reluctant to make huge investments into this activity at the moment. Two of the standard organisations examined even lack appropriate structures to understand climate change and the significance for the coffee business and are weak overall in the OLC steps (except for UTZ in knowledge absorption). All four interviewed agents are weak in adapting their processes, codes of conducts, and verification schemes to climate change and only assist the farmers with risk analyses and the implementation of proposed adaptation measures.

Implementers

The two investigated implementers are very strong in knowledge absorption and have generally strong capabilities in knowledge transformation and utilization. However, the implementers are only supporting agents in the coffee supply network and rather fulfil a moderating and assisting role as they are not directly impacted by climate change. Despite

their title 'implementer' that is used throughout the coffee network, these kind of organisations do not implement adaptation measures at the farm level, but only consult and support the smallholders in making their farms more resilient to climate change.

Scientists

The interviewed scientists with the specialisation in tropical agriculture are naturally very strong in knowledge absorption and use their expertise to develop adaptation strategies for the coffee business. However, despite the long term experience and tacitly held knowledge, the investigation revealed a lack of processes and structure to transform knowledge across the research institutes into a general knowledge base. As the research is very personalised and dependent on the researchers' interests and project contracts, the second OLC step is assessed to be weak in both cases. Similarly, scientists also do not carry out any adaptation as they are not directly impacted by climate change. Yet, both interviewees clarified that they also work directly in the field as part of projects and assist in improving good agricultural practices. Despite these efforts, scientists remain weak in the adaptation step.

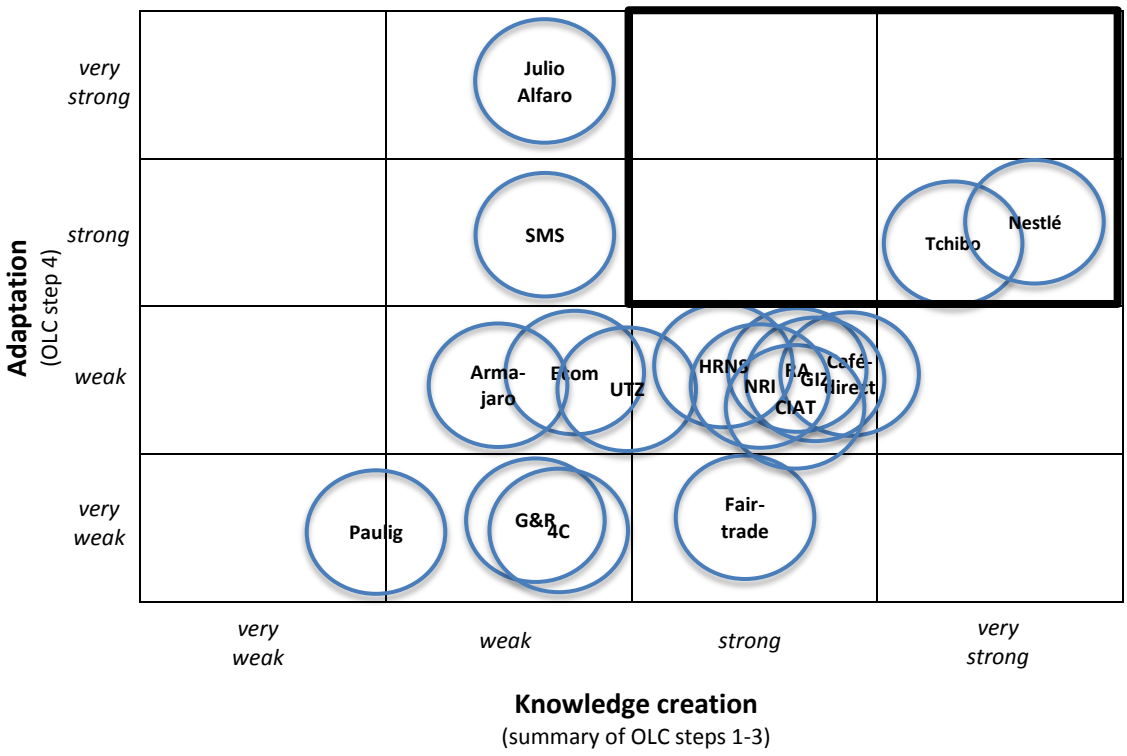


Figure 9-3: Relative positioning of organisations in a knowledge creation-adaptation matrix

Summary

In summary, all investigated organisations have weaknesses in one or the other OLC steps. Figure 9-3 illustrates the findings in a two by two matrix with the x-axis referring to knowledge

creation and the y-axis indicating the level of adaptation. Whereas knowledge creation summarises the first three OLC steps, adaptation represents the strength of an organisation in the final OLC step.

The figure clearly shows that the position in the top right quadrant is required to fully learn and eventually adapt an organisation to the impacts of climate change. However, the analysis of the different supply network agents revealed that only the two roasters are classified in this quadrant though are not strong enough to fully adapt their businesses to supply chain climate risk. The investigation further identified the farmers and extension services[18] to be in the top left quadrant which represents strong adaptation skills, but only little knowledge creation capabilities. In the bottom left quadrant, mainly the traders, small roasters, and two of the standard organisations are classified. They are relatively weak in knowledge creation as well as adaptation and take the least favourable position in organisational learning. Finally, the two leading standards organisations, scientists, GIZ, and Cafédirect are positioned in the bottom right quadrant which stands for strong knowledge creation abilities, but weak involvement in the implementation of adaptation measures.

Even though the clustering in this matrix is based upon the researcher's subjective assessment, the illustration of the research findings clearly shows that organisations are either strong in knowledge creation or in adaptation. Yet, most are unable to attain a position in the top right quadrant position requiring excellent competences criteria. For the coffee supply network, it can therefore be reasonably concluded that proposition 1,

P1*: Individual organisations in a supply network do not fully learn about climate change, i.e. they do not understand and adapt to climate risk*

can be verified.

With the emphasis on the farmers as they are the most exposed agents to climate change throughout the coffee supply network, their weak competences in knowledge creation prevent them from completing all four OLC steps independently from others and adapt their plantations without external input. As a supply network can only adapt to climate change if its exposed agents adapt to climate risks, it can further be argued that organisational learning is

[18] Extension services (e.g. SMS, etc…) are normally subsidiaries of traders, roasters, and sometimes implementers such GIZ, that are located directly in the coffee growing farmers and work together with the smallholders to improve their agricultural practices and livelihood.

insufficient to adapt the coffee supply network to the projected climate risk. Overall, the organisational learning processes of the individual agents are not carried out effectively enough to achieve network-level adaptation to climate change. As organisational learning is proven to be unsuccessful to enable the adaptation of the coffee supply network to climate change, the next chapter tries to determine what process of inter-organisational learning would be most successful in achieving the desired goal of supply network adaptation.

Chapter 10: Analysis of inter-organisational learning

10.1 Introduction

As the findings indicate that the organisations investigated in this research do not or only partially learn about climate change, this chapter investigates inter-organisational learning in the coffee supply network. It addresses the second part of the first research question and aims to reveal how inter-organisational learning can help the supply network to adapt to the risks associated with climate change. As a result, the second proposition: *Networks do learn and adapt to climate change (P2)"* can either be verified or rejected. For that reason, the four collaborative projects on adaptation in the coffee supply network as presented in the introduction (AdapCC; Sangana PPP; Coffee & Climate; and IDH Programme) are explored. The three projects and the programme are investigated in chronological order and focus on the learning cycle and the influencing factors in a complex adaptive supply network (CASN). Information is collected from conducted interviews with the different project partners as well as from project reports and websites (secondary data). Initially, the aim is to reveal the individual contribution of each project agent and to identify the flow of knowledge that leads to actual adaptation activities. Second, the influence of the four CASN factors (agents, network connectivity, dimensionality, and self-organisation/emergence) on the inter-organisational learning process is explored.

10.2 The AdapCC project

The AdapCC project (2007 to 2010) was carried out as PPP-project with GIZ as public partner and Cafédirect as major private partner. Additional stakeholders such as CIAT and different producer groups in the six focus countries (Mexico, Nicaragua, Peru, Kenya, Tanzania, Uganda) became also part of the project. Each country followed a learning process consisting of the phases: 'Information Gathering' (Knowledge absorption), 'Risk and Opportunity Assessment' (Knowledge transformation and utilization), and 'Implementation Adaptation Strategies' (Adaptation). After the first learning process was completed, the project then started a new learning cycle by comparing the outcomes of the different focus groups as part of the phases 'Impact Monitoring and Evaluation' (Knowledge absorption), and 'Cross Learning' (Knowledge transformation). This research focuses on the inter-organisational learning cycle for the Mexican case and discusses the contribution of each organisation in the following sub-sections.

10.2.1 Contribution of CIAT and Jeremy Haggar

CIAT contributed the scientific data and provided detailed climate projections for the Chiapas region in Mexico. It concluded that the agriculture will be highly affected by changes in

precipitation and water shortages as most of the country is semiarid. The most vulnerable regions to climate change are Chiapas Veracrux and Oaxaca as they represent the states with the highest forest biodiversity and biological productivity. A changing climate already caused forest fires and places the region in the first ranks of deforestation indices. Synthesising research from IPCC, the 'Centre for International Forestry Research' (UNAM), and own findings, CIAT predicted the following climate conditions and changes (AdapCC 2008):

- General increase in temperature by 2 to 4°C by 2050.
- Precipitation is predicted to decrease by 5% to 15% depending on the region.
- Changes in rainfall distribution
- Changes in soil and atmospheric humidity
- Increasing forest fires and deforestation
- El Niño years will display exceeding winter precipitation (floods, soil erosions etc…) and mark summer droughts, desertification of the land and the potential modification of regional ecosystems including drastic reductions in tropical and temperate forests.

Translating these projections into more tangible information, CIAT produced detailed maps at low resolution. As shown in Figure 10-1, the Chiapas region is very rugged with many valleys and mountains ranging from ca. 100 masl[19] to ca. 5,500 masl.

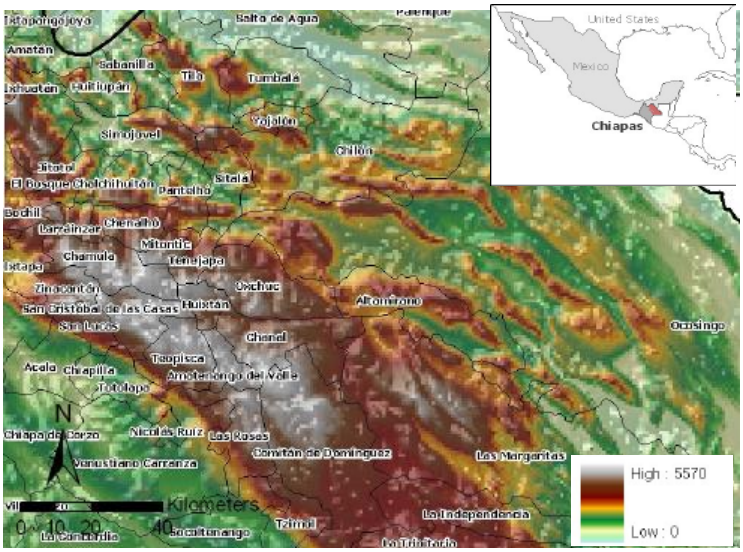


Figure 10-1: Topography of the Chiapas region, Mexico
Source: CIAT (2009)

[19] Metres above sea level

The analysis of the future climate conditions revealed significant changes in the suitability of coffee production in the Chiapas region. As illustrated in Figure 10-2, some areas are likely to increase the suitability of coffee growing whereas others will suffer from decreased suitability by 2050. The comparison between both figures clearly shows that lower areas will produce less coffee as the temperatures will be too high. However, new opportunities for coffee production will be generated as increases in temperature will make higher areas suitable for coffee production.

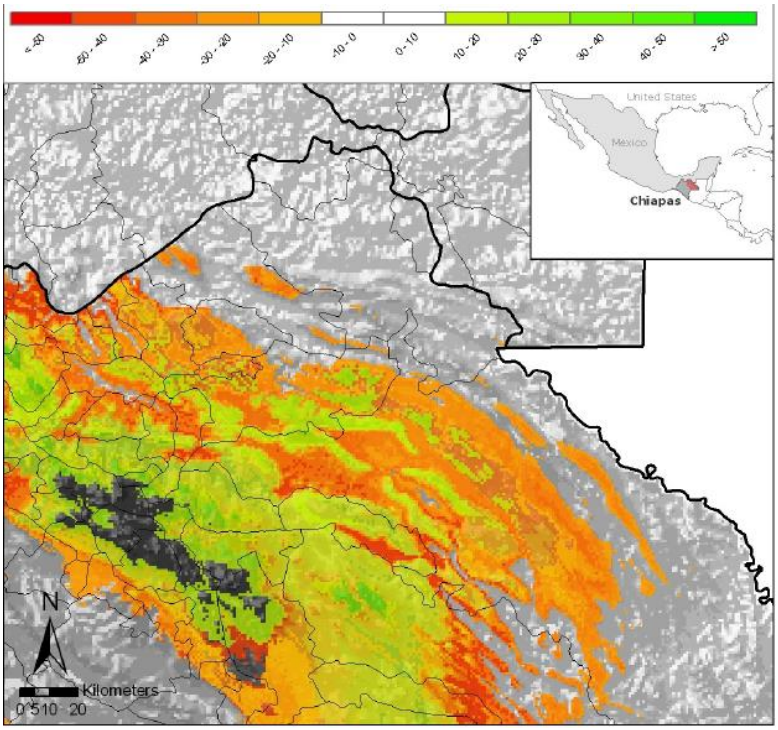


Figure 10-2: Changes in the suitability for coffee production by 2050 in %
Source: CIAT (2009)

In summary, CIAT in cooperation with other research institutes contributed forecasts of the suitability for coffee production in Chiapas over the next decades. Similar projections were produced for the other five focus regions of the AdapCC project and presented at different regional workshops. NRI, for example, contributed the scientific knowledge including an overview of climate change and localised projection of the future environmental conditions to the pilot case of Nicaragua. At a later stage of the project (January to February 2009), the scientist Jeremy Haggar contributed to the knowledge transformation and utilization step by designing a one week seminar to train the trainers for the 'Risk and Opportunity Assessment' (ROA) and by developing a training handbook. The capacity building programme resulted in the education of 26 trainers on the ROA process and enabled additional training of more farmers at a larger scale.

10.2.2 Contribution of Julio Alfaro/JSG

Julio Alfaro as member of the JSG co-operative was involved in all four steps of the inter-organisational learning cycle. As part of the knowledge absorption step, two representing cooperatives (JSG and Kulaktik) of Más Café[20] contributed the farmers' experiences of the impacts of climate change. Julio Alfaro assisted with the data collection process and conducted the interviews with the smallholders during July and September 2007. Nearly all farmers reported observations of a changing climate over the last 20 years. The Chiapas region suffered from an overall decline in the quality and quantity of green coffee caused by the problem of climate change as summarised in Table 10-3.

Problem/Risk	Root causes
Deforestation	- Increasing temperature lead to drying up of surrounding areas and causing bush fires - Lack of environmental conservation techniques
Less water availability	- Lack of rainfalls - Lack of water catchment installations - Deforestation
Increasing pests	- Rise in temperature - Strong rains (worms plague) - Loss of native vegetation - Loss of shade trees - Excessive application of pesticides
Poor soil fertility	- Accelerated soil erosion due to extreme weather - Prolonged droughts - Excessive use of agrochemicals
Difficulties in drying coffee beans under the sun	- Excessive use of agrochemicals - Changing precipitation patterns - Rain during the harvest season (January and February) when coffee beans are dried
Erratic rains and strong winds	- Increased extreme weather events like hurricanes - Landslides in higher altitudes - Flooding in lower altitudes

Table 10-1: Summary of risks and causes associated with climate change for farmers in Chiapas
Source: adopted from AdapCC (2010)

Julio Alfaro and the JSG cooperative were also involved in the knowledge transformation and utilization steps. A number of workshops with farmers and implementing agents were held in Chiapas to discuss the experienced impacts and the climate projections provided by CIAT. As a result, the project partners concluded on a Risk and Opportunity Assessment process comprising 7 steps (see Figure 10-3). The ROA process aims to help farmers to identify the risks associated with climate change, collect appropriate data to triangulate observations and

[20] Más Cáfe counts around 2,250 producer members of eight coffee cooperations

scientific findings, and to develop adaptation measures that can be applied to the local impacts. The participatory approach in which farmers were directly involved in the risk assessment process resulted in a detailed implementation plan of the identified adaptation strategies that also includes options to finance adaptation. Between January and November 2008, the developed ROA process was tested with CEPICAFE[21] in Peru and PRODECOOP[22] in Nicaragua. After some refinements, the second field test was carried out with Más Cáfe in Mexico and Michimikuru [23]in Kenya.

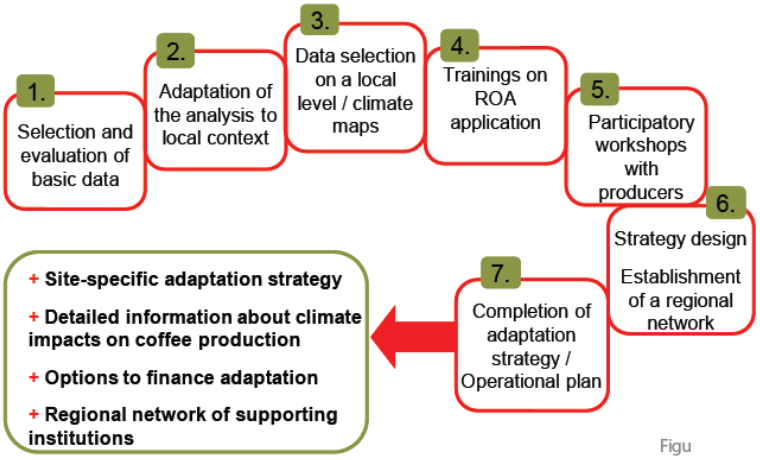


Figure 10-3: 7 steps of the AdapCC Risk and Opportunity Assessment (ROA) process
Source: AdapCC (2010)

Based on the ROA process, the project partners developed five key strategies (Maintain and increase Forest Cover; Pest Management; Secure Coffee Drying Process; Carbon Sequestration; Energy efficiency) to improve good agricultural practices that were implemented by Más Cáfe between November 2008 and January 2010. As the two latter strategies rather address climate mitigation activities, the first three strategies on adaptation and their actual implementation activities are presented in more detail in Table 10-2. They serve as exemplified measures for other producer groups. Adaptation strategies include short term measures such as an improved irrigation system, but also long term measures such as capacity building for long term financial and technical support. The project partners also worked on more resistant crop varieties and surveyed the possibility to increase income from climate friendly certified products to finance adaptation measures. Finally, adaptation might also be achieved through diversification of farmer's income to reduce the dependency on monocultures such as coffee.

[21] A Fairtrade cooperative in Peru representing ca. 6,000 small holder producers
[22] A cooperative in Nicaragua representing ca. 2,300 small holder producers
[23] A cooperative in the Kenyan tea sector that represents ca. 10,000 small holder producers

Yet, this strategy is still controversially discussed as it only adapts the farmers and not the coffee supply network to climate change.

Strategy	Implementation
Maintain and increase Forest Cover	- Extension of Más Cáfe's tree nursery to 450,000 plantlets per cycle - 24 local services were trained to collect native tree seedlings - 12 sensitization workshops were held per cooperative
Pest Management	- Two agreements signed not to use chemical pesticides - More than 10 workshops on Pest Management - 80% of producers planted hedges to improve soil fertility - 90% of farmers produce compost
Secure Coffee Drying Process	- Exchange visit to Nicaragua to learn about alternative drying techniques - 30 solar dryers as demo units were installed - Communal workshops to enhance farmers' wet milling practices

Table 10-2: Más Cáfe's adaptation strategies to climate change
Source: adopted from AdapCC (2010)

10.2.3 Contribution of GIZ

GIZ[24] took the role of a public organisation and financed 48 per cent (300,000 EUR) of the PPP project. It co-ordinated all activities throughout the different regions and had the project headquarters at GIZ's 'Department for Rural Development and Natural Resources Management' in Eschborn, Germany. GIZ provided the global network structure and resources for rural development (GIZ operates in 130 countries worldwide) and therefore contributed expertise from its own activities on the ground to the knowledge absorption and transformation step. The generated knowledge was combined with the 'Risk Analysis for Disaster Risk Management', previously developed by GIZ for another development programme, and used to design the 'Risk and Opportunity Assessment' (ROA) framework. Whereas GIZ was not involved in the adaptation step, the findings of the project were disseminated by the organisation to scale up the application of ROA and the actual implementation of adaptation measures across the sector. For that reason, GIZ set up an expert meeting in Germany in October 2009 and multiple regional workshops to transform knowledge between the different coffee growing regions. GIZ also took responsibility to publish all findings for each focus region and the final AdapCC report as knowledge input for other inter-organisational learning cycles.

[24] In the case of AdapCC, GIZ's predecessor organisation GTZ was the project partner in the project. However, for consistency reasons, GTZ is referred to as GIZ in this case.

10.2.4 Contribution of Cafédirect

Cafédirect initiated the AdapCC project together with GIZ and aimed for more information about the conditions and problems farmers face as a result of climate change. The organisation contributed almost 50 per cent of the financial resources and benefited from GIZ' global network and expertise. As the project was limited in its resources, six pilot regions from Cafédirect's global network of 39 producers were select. Cafédirect managed the selection of the pilot groups together with the producers in a participatory way and according to criteria such as the severity of climate change effects, the producers' vulnerability, and their adaptation capabilities. Scaling up the results from the pilot cases, the company disseminated the findings to the remaining producer organisation, but also to the public to raise awareness of the climate change problem and trying to attract additional funding for subsequent projects. Cafédirect was predominantly involved in the knowledge transformation and utilization steps. As a project initiator, the organisation co-ordinated the differently held knowledge to form a mutual knowledge base and contributed with the roasters' perspective to the design of the ROA process. Cafédirect was not involved in the adaptation step, but observed the implementation process to understand the success factors that could be transformed to other producer organisations in Cafédirect's global network and across the entire coffee sector. As a result, the company has been financing farmers via the Cafédirect Producer Foundation to actually implement the adaptation measures.

10.2.5 Inter-organisational learning of the AdapCC project

AdapCC is a good example for inter-organisational learning as the project partners combined their organisational strengths to develop a risk and opportunity assessment process which enabled farmers to identify the impacts of climate change and to implement location specific adaptation strategies. As shown in Figure 10-4, farmers from the pilot cases (e.g. Julio Alfaro, etc…) as well as NRI and CIAT contributed practitioner and scientific knowledge of climate change. Mainly, GIZ and Cafédirect as initiators of the PPP project transformed and utilized the knowledge to develop the ROA process. CIAT supported the scaling up process by providing a handbook for farmers of how to apply the ROA framework. The final adaptation step was left to the farmer community, but was overviewed by other project partners to assess the practicability of the developed adaptation strategies. Further, Cafédirect and GIZ used their network to disseminate the project findings to the wider producer community and public to raise awareness and attract more financial funding for adaptation activities. As a result, initial thoughts came up to strengthen the collaboration with Fairtrade and 4C. The latter was considered to serve as knowledge hosting platform that could provide climate data and training material throughout the coffee network. On the other hand, the Cafédirect Producer

Foundation thought about using the Fairtrade premiums which are paid directly to the farmers, to fund the actual implementation of the ROA process at producer communities which have not been involved in the project so far.

SN Agents	*Representing*	*Four Phases of the Inter-Organisational Learning Cycle*			
		1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
Project period from:		**April 2007 to November 2008**			**Nov 08 - Feb 10**
CIAT	*Scientists*	Contribution of climate data; scientific evidence; synthesising research findings from different institutes; creation of maps of future coffee growing suitability by 2050. Indicating new areas for coffee production and clarifying that farmers at lower altitudes will suffer the most.			
Julio Alfaro	*Farmers*	Observations and experiences of the impacts of climate change on the coffee growing process; suffering from erosion, deforestation, less water availability, increasing pest; changing precipitation patterns, extreme weather events such as hurricanes.	Producers contributed with possible adaptation solutions to the ROA process in order to improve good agricultural practices.		Implementation of adaptation measures; Maintain and increase Forest Cover; Pest Management; Secure Coffee Drying Process.
Cafédirect	*Roaster*		Initiated the PPP project and selected the pilot regions; set up of project aim and structures. Contributed with the roasters' perspective to the ROA process.		
GIZ	*Implementers*		Contributes first-hand knowledge of the impacts of CC; represents the public partner in the PPP project and put in half of the funding. Neutral organisation who co-ordinates the different interests of all SC tiers. Provides basic concept for the ROA process.		
Project period from:			**January 2009 to February 2010**		
GIZ	*Implementers*		Dissemination of results & scaling up; expert meeting at GIZ, Germany (October 2009); multiple regional workshops to raise awareness of the project outcomes; encourage others to apply the ROA process and adapt to climate change.		
Jeremy Haggar	*Scientist*			Design of a one week seminar to train the ROA trainers; development of training handbook.	
Cafédirect	*Roaster*		Dissemination of results & scaling up; contact and coordination of workshops with pilot producers from its network. Dissemination of results to the entire Cafédirect network of producers. Financial support of farmers via Cafédirect Producer Foundation.		

Figure 10-4: Inter-organisational learning of the AdapCC project

10.3 The Sangana PPP

Over the three year period (2008 to 2011), 8 partners contributed with different input, activities, and resources to the pilot project in the Baragwi coffee producing region in Kenya. All project partners met at a conference in Lausanne on 29th September 2011 to discuss the findings and future actions. Dependent on their organisational learning abilities, each project partner contributed to the inter-organisational learning cycle. The following sub-sections discuss how each partner benefited form the strengths of others and highlight the flow of information and knowledge within the project comprising multiple partners from the coffee network.

10.3.1 Contribution of NRI, CIAT, and BFCS

For the NRI, Jeremy Haggar contributed with the latest scientific findings on climate change. He presented a general overview of the future climate at the Lausanne conference and concluded that coffee production can adapt to a changing environment by comparing risks and opportunities as summarised in Table 10-3. Whereas the risks of climate change are backed by scientific research, the opportunities are presented as recommendations to be discussed across the coffee network.

Risks of climate change	**Opportunities of climate change**
Some areas will go out of coffee production	Other producers will learn to adapt their production systems
There will be more frequent damage from hurricanes	There will be some new producers, but maybe not enough
Income will be more variable and more producers will go broke	The insurance business may take over some risks
There will be greater variability in supply and quality of supply	New varieties might be found that are less sensitive to climate change
Prices will be more volatile, but possibly generally higher	The sector will adapt best when it has strong alliances amongst all SN agents

Table 10-3: NRI summary of risks and opportunities of climate change
Source: Haggar (2011)

More specifically to the Kenyan region, CIAT contributed scientific knowledge of the impacts of climate change in that region. Making them more tangible to the other partners, recent future climate projections from CIAT and the IPCC at a larger resolution were scaled down to the needs of the Baragwi growing areas. For the investigated region, CIAT forecasted changes in climate conditions by 2050 as summarised in Table 10-4. The analysis revealed a significant temperature increase that impacts on the seasonality and intensity of rainfall. Moreover, growing suitability is likely to decrease, with the exception of a smaller area within the Baragwi

region. Taking into account these changes, CIAT concluded that the optimal growing altitude will increase by 100 masl, and that higher altitudes generally benefit from climate change, whereas lower altitudes will suffer from a decline in growing suitability.

Factor	Projection by 2050
Average temperature	Increase by 2.3°C
Rainfall	• Increase from average 1450mm to 1575mm • Less seasonality
Growing suitability in the total region	• Overall decrease from 60-80% to 30-50% • The special region of "Rift Valley" will gain suitability by 20-30% in comparison to 2012 • Altitudes around 1200 to 1300 masl will suffer the highest decrease • Areas around 2000- 2200 masl will experience the highest increase in suitability
Optimal growing altitude	Shift from currently 1.600 masl to 1.700 masl.

Table 10-4: Climate projections in the Baragwi region (Kenya) by 2050
Source: CIAT (2010)

Based on these findings, CIAT illustrated the impacts on the growing suitability and provided three maps that demonstrate the negative development of growing suitability in the Baragwi region (see Figure 10-5). The projections indicate that already by 2020, some Baragwi processing facilities will be located in less suitable production areas. By 2050, at least three facilities will be outside the region in which coffee can currently be grown.

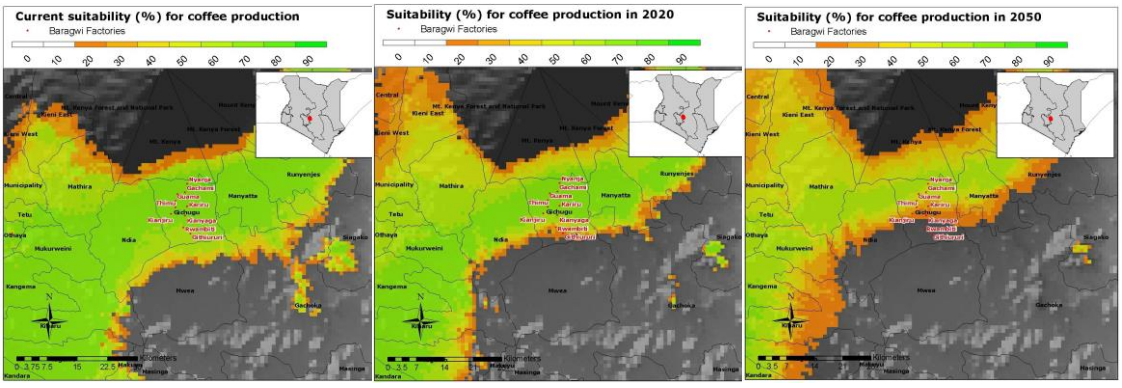


Figure 10-5: Changing growing suitability in the Baragwi region by 2020 and by 2050
Source: CIAT (2010)

In conclusion, CIAT provided the scientific knowledge by forecasting future climate conditions the farmers are likely to face by 2020 and 2050. CIAT contributed to the knowledge transformation process within the project by translating the scientific findings into a more

practitioner-friendly language and by creating maps that enabled an easy understanding of the impacts on the region.

The Baragwi Farmers' Cooperative Society (BFCS) contributed with experiences and observations about the impacts of climate change. Farmers have increasingly begun to suffer from erosion, deforestation and plantlet diseases as a result of changing climate conditions. Extreme weather events such as hail and frost impacted on the plantations. As farmers were unable to respond to the experienced impacts, BFCS produced significantly less green coffee and demanded for support from other project partners and SN agents. BFCS also actually implemented the suggested improvements in agricultural practise in order to adapt the farms to the impacts of climate change. This final step in the network learning cycle was solely carried out by BFCS even though the farmers benefited from advisory services and trainings offered by GIZ and SMS.

In summary, NRI, CIAT and BFCS contributed knowledge of the impacts of climate change to the project. Whereas NRI and CIAT offered valuable and detailed information about the likely growing conditions in the future, BFCS provided comprehensive knowledge of the experienced impacts from a practitioner's perspective. The three partners took part in project workshops and contributed to the knowledge transformation step. BFCS was also the recipient of the developed adaptation strategies and actually adapted the farms to changing environmental conditions.

10.3.2 Contribution of SMS and GIZ

SMS and GIZ were involved in all four inter-organisational learning steps. Both organisations have first-hand knowledge of climate change as technical and support staff from the organisations experienced the impacts of a changing environment directly on the ground in the producing countries. Using their organisational knowledge, they contributed to the transformation step by presenting their observations at the Lausanne conference. They added valuable input to the development of the 4C climate module by contributing expertise on possible approaches to improve agricultural practices and by ensuring that the module did not become dictatorial, but a joined adaptation effort with the farmers. GIZ was also the public partner in the project. The organisation put in almost fifty per cent of the funding and also took the role of a neutral organisation with a proven track record of development projects. SMS focused more on the support of the farmers to implement the 4C climate module. It held training sessions with the farmers to raise their understanding of the impacts of climate change and to introduce the 4C climate module. The training comprised a one day introductory training course as well as subsequent field sessions to present methodologies

that help farmers to identify their exposure to climate change. Further, SMS assisted the smallholders in improving their agricultural practices by actually implementing adaptation measures such as better water supply and mulching, for example, that have been identified by the project partners to make the Baragwi region more resilient to climate change.

10.3.3 Contribution of Ecom and Tchibo

Ecom (trader) and Tchibo (roaster) were initially not part of the Sangana PPP, but joined the project shortly after its start. Both organisations were mainly involved in the knowledge transformation and utilization steps in the learning cycle. David Rosenberg from Ecom organised and moderated the Lausanne workshop and eventually ensured that all project partners reached the same level of knowledge. Ecom as second tier in the supply chain after the farmers had a strong interest in understanding the needs for the coffee sector as a result of a changing environment. Therefore, the company invested 15,000 USD into the project. Ecom's subsidiary SMS worked with the farmers on the ground whereas the transformed knowledge was utilised at the corporate level to contribute to the development of 4C's climate module. Ecom utilised the absorbed knowledge to emphasise on the need for 'thinking bigger' when developing a climate module. The trader took a rather critical position of the project outcome as such a small project seemed to be unable to close the gap between what the coffee sector requires and what such kind of projects could offer. Ecom argued that the project only considers a handful of farmers and that possible adaptation measures must be applicable to millions of farmers. The company takes the position that the things farmers can do are relatively simple and are already part of good agricultural practices. And the things that need to be done, such as financing adaptation in the form of more robust trees, for example, must be delivered by other SN agents and cannot be afforded by the farmers. In summary, Ecom recognised the learning value of the project and contributed to the project by clarifying that the coffee business needs to start thinking at larger scale when developing climate modules to make the supply network more adaptable.

Tchibo's role in the project was also mainly in the knowledge transformation and utilization learning steps even though it contributed some expertise from its work with farmers. The organisation presented the roasters' perspective at the Lausanne conference that the trade seems to be unable to fulfil its function of consistently supplying green coffee to the roasters in times of climate change. This position has been developed over the last few years and led to the fact that all major coffee brands are nowadays working directly with farmers on the ground and in collaborative projects on climate change adaptation. As part of the knowledge transformation phase, Tchibo aimed to reveal the impacts of climate change on the Arabica

growing regions and whether supply and demand for this high quality coffee could be matched under changing future conditions. Tchibo contributed to the knowledge utilization phase by stressing that a standardised approach for adaptation is needed and that investments should be made on adaptation rather than on mitigation efforts, such as carbon measuring tools, for example. Tchibo ensured that the project outcome was accessible to all project partners and that possible adaptation solutions could be scaled up to the wider farmer community.

10.3.4 Contribution of 4C

4C was mainly involved in the knowledge utilization step of the inter-organisational learning cycle as one of the project aims was to develop a climate module that could be added to the 4C Code of Conduct. The analysis of 4C's organisational learning revealed weak capabilities in all four OLC steps. For that reason, 4C took a rather recipient role and benefited from the project's capabilities in knowledge absorption and transformation. By integrating different viewpoints and needs, a voluntary add-on module could be developed that addresses adaptation as well as mitigation tools. The resulting standard could then be used across the entire sector and is likely to be highly accepted as different interest groups were involved in the development process. Based on the created knowledge of climate change and the requirements as defined by the project partners, the 4C climate module was created as summarised in Figure 10-6.

4C Climate Module

Climate code	Training	Verification	Climate data base
Agricultural practices for adaptation and mitigation - Enabling/cultivation of the environment - Natural Resource Management - Soil and Crop Management - GHG Emission Management	*Trainings for Producers and Verifiers* Cooperation with local implementing organisations such as GIZ and SMS	*Necessary tools* Cooperation with organisations that already verify farms against the different standards in the sector and that can then also verify the 4C climate module (adaptation and mitigation measures)	*Scientific information and climate data* Cooperation with research institutes such as CIAT and NRI to obtain localised data on climate change impacts.

Figure 10-6: The 4C Climate Module
Source: adapted from Sangana PPP (2011)

The climate module comprises the four key elements training, verification, climate data base, and climate code, whereas the latter is the heart of the module. As farmers are the most

vulnerable to climate change, the module predominantly tackles climate change directly in the countries of origin. Implementing partners such as SMS and GIZ can then use the standard to train the farmers and help them improving their agricultural practices. Finally, verification organisations survey the implementation process and verify farms with the compliance of the 4C code of conduct including the newly added climate module.

10.3.5 Inter-organisational learning of the Sangana PPP

The investigation of the Sangana PPP revealed very good inter-organisational learning capabilities as the collaboration between the different project partners enabled the full completion of the learning cycle. Figure 10-7 illustrates the inter-organisational learning process and shows the flow of information and knowledge between the project partners. Knowledge absorption was mainly carried out by NRI, CIAT and the Baragwi Farmers' Cooperation Society (BFCS). Others (SMS, GIZ, and Tchibo) contributed their knowledge of the impacts of climate change to the project. The latter three and the trading company Ecom were then involved in the knowledge transformation and utilization processes. Together with the coffee platform 4C, the partners discussed the development of a climate module that encompasses techniques to help farmers adapting to the changing environment. The actual implementation was carried out by BFCS with the support of technical staff from SMS and GIZ. By combining different roles, the Sangana PPP is a successful example of inter-organisational learning.

All organisations took part in the Lausanne workshop and CIAT, NRI, and BFCS presented their knowledge of climate change. In particular, the second learning step (knowledge transformation) revealed a number of issues to be considered when designing the 4C climate module:

a) The flow of information between the SN agents should be improved. On the one hand, climate change is highly complex and requires strong efforts in scientific research to be fully understood. In order to make climate change accessible to farmers, a much easier language and simplified illustrations are therefore needed to explain the significance for the production process to the smallholder community. On the other hand, more primary data on coffee trees, productivity, and observed changes in the countries of origin should be processed from the farmers to other SN agents. Accordingly, a mix of scientific and participatory approaches is needed to enable adaptation.
b) Producers have their localised approaches to respond to the impacts of climate change and therefore must be involved in finding solutions at a larger scale.

c) The outcome of the knowledge transformation step led to the conclusion that more awareness rising of climate change is required as most farmers do not make the link between climate change and the noticeable decline in productivity.
d) Funding for adaptation is one of the biggest challenges.
e) For the coffee business, adaptation to climate change is more important than mitigation, even though adaptation activities might have a mitigating effect.
f) Inter-linked local, regional and global networks are necessary for successful adaptation as the developed adaptation strategies at the global level require localised structured and processes in the countries.
g) The implementation of adaptation measures requires commitment from the farmer community and technical support from supporting SN agents.

The created knowledge base from the second learning step was then used to design the 4C climate module. The project partners decided to split the module into four sections, each addressing the findings and requirements as revealed from the knowledge transformation step. The 'Climate Code' addresses a collaborative approach to improve agricultural practices and to enhance framework conditions for funding [(a), (b), (d), (f)]. The component 'Trainings' refers to the need of supporting farmers when implementing the adaptation strategies on the ground and to raise the awareness of the impacts of climate change on the coffee production [(c), (e), (f), (g)]. 'Verification Instruments' are part of every code of conduct to verify the compliance with the rules. In this case, appropriate instruments were established to verify the implementation of adaptation measures. The 'Climate Data Base' is the final component of the climate module and addresses the need to integrate scientific findings such as projections of the future climate conditions in the growing regions, but also to collect farmers' experiences of the impacts of a changing environment [(a), (c)].

In summary, the Sangana PPP revealed evidence for inter-organisational learning that resulted in the adaptation to climate change through changes in agricultural practices in the Baragwi region. As a result of the collaborative development and successful testing of the 4C climate module, relevant scientific and practitioner data were collected, several workshops were held to train the farmers, tools to verify the implementation of adaptation measures were applied, and actual adaptation in the form of almost tripling the outcome of produced coffee was achieved in this particular region within one year. This result was only possible as all four steps in the learning cycle were addressed by a number of SN agents who collaboratively worked together.

SN Agents	*Representing*	*Four Phases of the Inter-Organisational Learning Cycle*			
		1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
CIAT/NRI	*Scientists*	General overview of the future climate; maps of future climate conditions globally and for selected countries (NRI). Scientific projections of climate conditions by 2050, development of coffee growing suitability maps; average decline by 30%; less seasonality in rain and drought (CIAT)			
BFCS*	*Farmers*	Observations and experiences of the impacts of climate change on the coffee growing process; suffering from erosion, deforestation and plantlet diseases; and extreme weather events such as hail and frost. Consistent decline in total weight of cherries supplied from 5.7 mio kgs in 2008/9 to 2.5 mio kgs in 2010/11.			Implementation of adaptation measures; improved water supply through rising water levels and diversion of rivers, increased productivity. Forecasted output of cherries of ca. 7 mio kgs in 2011/12.
SMS	*Implementers*		Contributing with first-hand knowledge of the impacts of CC; ensured that farmers' needs are considered in the climate module. Carried out workshops with farmers to introduce the 4C climate module and assisted in the implementation of adaptation measures		
GIZ	*Implementers*		Contributing with first-hand knowledge of the impacts of CC; ensured that farmers' needs are considered in the climate module. Assisted with technical staff during the implementation step. Represented the public partner in the PPP project and put in half of the funding. Neutral organisation who co-ordinated the different interests of all SC tiers.		
Ecom	*Traders*		Organiser and moderator of the coffee and climate conference on 29th September 2011, Lausanne. Represents the traders' position on CC adaptation that flows into the development of the 4C climate module. Emphasis strongly on a scalable climate module		
Tchibo	*Roasters*		Represented the roasters position on CC adaptation that flows into the development of the 4C climate module. Emphasised strongly on adaptation rather than mitigation. Driving force of sector collaboration on adaptation as Tchibo is exposed to CC due to its 100% Arabica sourcing strategy.		
4C	*Standards*			Development of the 4C climate module and testing as part of the project with the partners. *Climate code* (Ecom, Tchibo, SMS, GIZ, BFCS), *Training* (GIZ, SMS), *Verification instruments* (local organisations, 4C), *Climate data base* (CIAT, NRI).	

* Baragwi Farmers' Cooperative Society Ltd; not interviewed; information obtained from secondary data sources and interviews with other organisations in the same supply network.

Figure 10-7: Inter-organisational learning of the Sangana PPP

10.4 The Coffee & Climate project

The 'Coffee & Climate' project (September 2009 to September 2013) was carried out as PPP-project and acted as a platform to enable dialogue and exchange of information and experience between academics, NGOs, government organisations, farmers, roasters and traders. GIZ took the role of the public partner and collaborated with a number of private partners from different SC tiers (Tchibo, Paulig, Neumann Foundation[25], Ecom, and others). Scientific expertise was contributed by CIAT, NRI, CABI[26], and Embrapa[27]. The project conducted field research in four pilot regions: Tanzania and Guatemala/Honduras/El Salvator to represent Arabica production; and Brazil and Vietnam to represent Robusta production, intensive and diverse production systems as well as wet and dry processing. Building a bridge between climate change experts and smallholder coffee farmers, the project aimed at becoming a reference point and information centre for SN agents worldwide interested in supporting climate change adaptation and mitigation processes in the coffee sector. The following sub-sections discuss the contribution of each investigated project partner, but limit the analysis to the case of Vietnam. This region was selected as it is the world's largest Robusta producer with 40 per cent market share (Marsh 2007). Moreover, unsustainable cultivation practices (high yield monoculture with strong deforestation, land degradation, water irrigation and intensive use of fertilizer) make coffee plantations highly vulnerable to already perceived and future climate change. As a result, the 2010/11 harvest output in the Vietnam regions declined by ca. 20 per cent compared to previous years (Haggar 2011).

10.4.1 Contribution of CIAT and NRI

CIAT and NRI contributed to the knowledge absorption step in the inter-organisational learning cycle and created country specific forecasts of the future climate conditions and the impacts on the coffee production by 2020, 2050 and 2090. The results for the coffee growing provinces in Vietnam showed that the changes in suitability for production as a result of climate change are site-specific. However, CIAT and NRI concluded on the following climate forecasts and impacts on the coffee production (synthesised from Haggar 2011 and CIAT 2012):

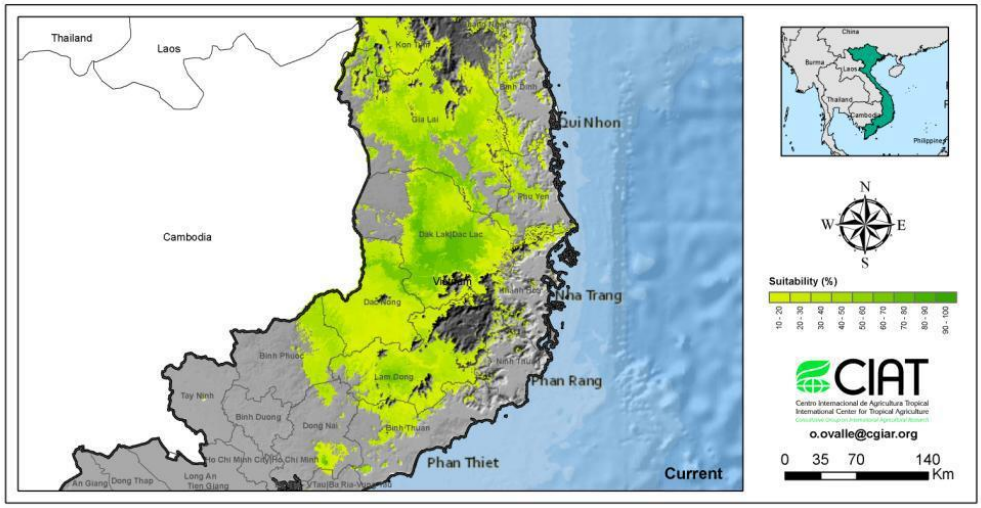
- The yearly and monthly rainfall will decrease by 2020 and progressively increase by 2050.

[25] Neumann's subsidiary consultancy firm 'Embden Drishaus & Epping Consulting' (EDE) carried out the field research in Vietnam.
[26] Centre for Agriculture and Biosciences International
[27] Brazilian Agricultural Research Corporation

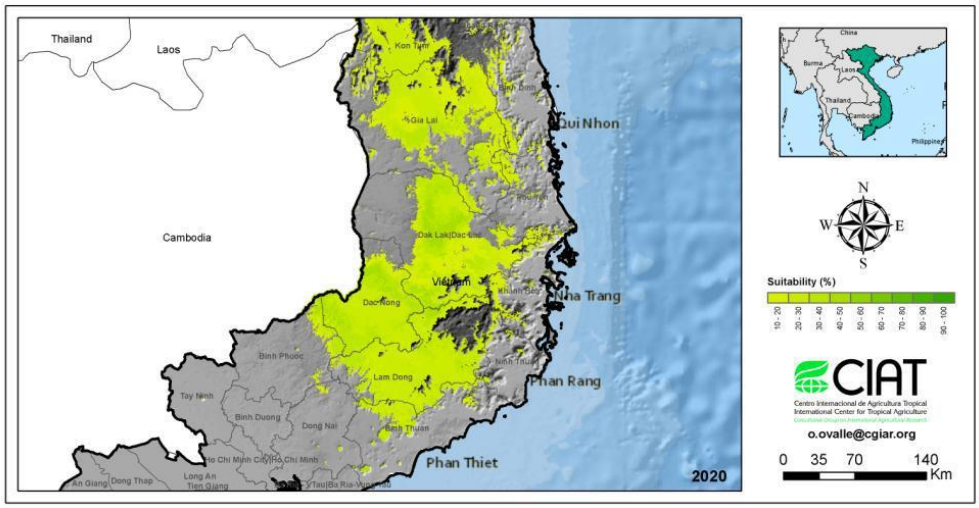
- The yearly and monthly minimum and maximum temperatures will increase by 2020 and progressively increase by 2050; in specific districts by about 0.7ºC by 2020 and 1.8ºC by 2050; temperature is expected to increase by 1.4 to 4.2°C by 2090.
- The optimum coffee-producing zone is currently at an altitude between 300 and 900 masl and will increase to an altitude between 600 and 1000 masl by 2050.
- Compared with today, areas at altitudes between 300 and 550 masl will suffer the highest decrease in suitability and the areas around 850 masl will not change significantly in suitability by 2050.
- The seasons will be more pronounced: the dry season will be drier and hotter; mainly in the wet season, for the Central Highlands where coffee is grown, the number of hot days is expected to raise to 94 in 2020 and 134 in 2050; the rainy season will be wetter and hotter with the maximum number of cumulative dry months decreasing from 5 months to 4 months; the total rainfall is expected to increase by 2 to 14% by 2090s, mainly due to increasing extreme weather events from June to October.

As illustrated in Figure 10-8, the distribution of suitability within the current coffee-growing areas in Vietnam for Robusta coffee production will decrease by 2050. Whereas some areas will become unsuitable for coffee production (DakLak, Gia Lai, DongNai), others will suffer from losses in suitability for coffee growing by ca. 50 per cent, but will remain suitable if farmers adapt (Lam Dong, DakNong). There will also be areas where currently no coffee is grown, but which will become suitable in the future. As increasing altitude compensates for the increase in temperature, those areas will be especially in mountain regions. Yet, most of them are protected natural areas which are unlikely to be forest cleared for coffee production. Therefore, new opportunities for coffee production will not compensate the projected losses in Vietnam (CIAT 2012). To cope with the reduction in growing areas, Vietnam farmers need to increase productivity. However, this objective is also challenging as the precise use of water will be decisive. River flows in the South are expected to decline, groundwater is expected to drop up to 11 m compared to the current level, and demand for irrigation in agriculture is calculated to be two- to threefold compared to today's demand. For example, in Dak Lak, the main issue in water resources management is the competition for water between domestic uses and irrigation of coffee. In 1994 and 1995 the city of Buôn Ma Thuôt suffered critical water shortages of 10 litres per capita per day (Andersen, 2001). This trade off might lead to the decision, that water availability for coffee production will not be given priority and furthermore might result in the decrease in productivity and overall green coffee production.

a) Current suitability of Robusta coffee production



b) Suitability of Robusta coffee production by 2020



c) Suitability of Robusta coffee production by 2050

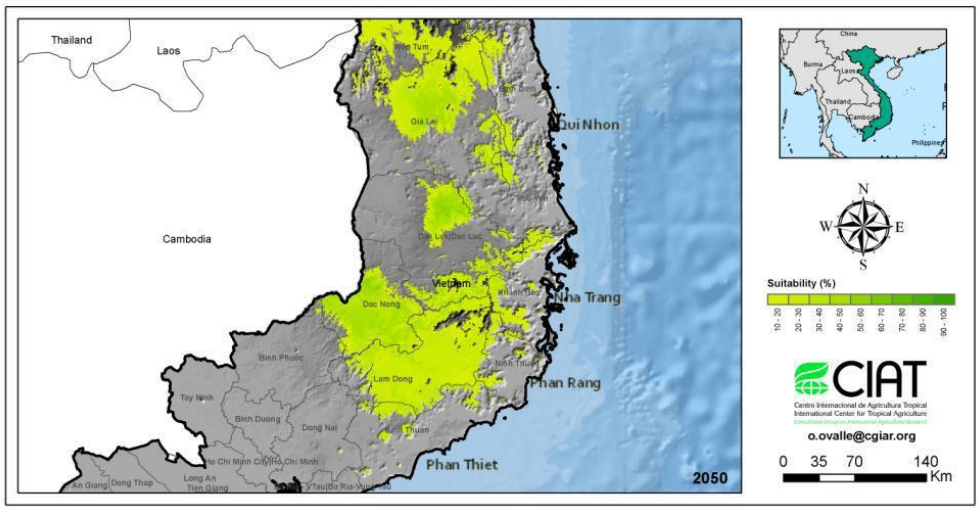


Figure 10-8: Comparison of current and future suitability (by 2020 and 2050) of Robusta production in Vietnam
Source: CIAT 2012

In summary, mainly CIAT provided the future climate scenarios for the Vietnam coffee regions and transformed the highly complex climate modelling techniques to a more practitioner-friendly language. The created climate maps enable easy access to the topic of climate change and raise awareness across the sector at a larger scale. Yet, CIAT also argued that its contribution was limited to the knowledge absorption step as it was sub-contracted to consult the project partners on the future environmental conditions. Besides the presentations of the result in the knowledge transformation step, CIAT was not involved in the two remaining learning steps.

In turn, NRI also contributed to the knowledge transformation and utilization steps by offering adaptation strategies to be integrated in the outcome of the project. Haggar (2011) proposed 7 adaptation measures to be considered:

- **Water management and irrigation**: Huge potential to improve water efficiency as the current amount of water used for irrigation (600 to 900 litres per tree) could be reduced to 320 litres per tree to achieve the same yield.
- **Soil management**: Measures to enhance the resilience of soils should be implemented to avoid serious damages and yield loss (e.g. organic fertilization; planting trees and bushes that help to prevent from soil erosion and landslides; and enhancement of water storage capacities of the soils).
- **Diversification:** To enhance the resilience of the agricultural production system to climate change, options to diversify production and farmers' income should be identified. Diversification might become the main tool that farmers have to reduce their individual farm risk. However, farm diversification is not always easy as there are often no clear profitable options and the financial costs of changing crops are high. Possible options comprise the production of rubber, cashew, pepper, corn, and cotton.
- **Sustainable coffee cultivation practices:** Avoidance of further de-forestation and application of climate modules from standard organisations such as provided by 4C or Rainforest Alliance.
- **Research:** More support from scientific research institutes is required as impact scenarios on coffee cultivation will help farmers to design adaptation strategies and instruments to the local needs.
- **Capacity building and training:** External support from implementing services that have more capacities and technical resources are needed to scale up adaptation. Such organisations could provide implementation plans and technical assistance. Also

administration should be trained on adaptation to allow them integrating their knowledge into regional and national adaptation plans.

- **Financing and insurance:** Farmers' access to financial support and risk management systems needs to be improved. This may include special loans to farmers if they wish to follow diversification plans, for example.

10.4.2 Contribution of farmers and local experts

Farmers and local experts contributed their field observations and expertise to the project. In the pilot region of Vietnam, the scientist Peter Baker together with Neumann's subsidiary consultancy 'EDE' conducted the field research and interviewed 25 farmers on climate change. As shown in Figure 10-9, the smallholders reported various production problems of which pest and disease, irrigation, and weather could be directly and indirectly linked to climate change (Baker 2012). In total, the 'Coffee & Climate' project reached 178 farmers in the coffee growing areas of Vietnam who reported similar problems such as difficulties in cultivation, changes in rain and dry season, and decreasing yields and coffee quality. In comparison to 2010/11, the 2011/12 coffee production decreased by ca. 20 per cent (Haggar 2011).

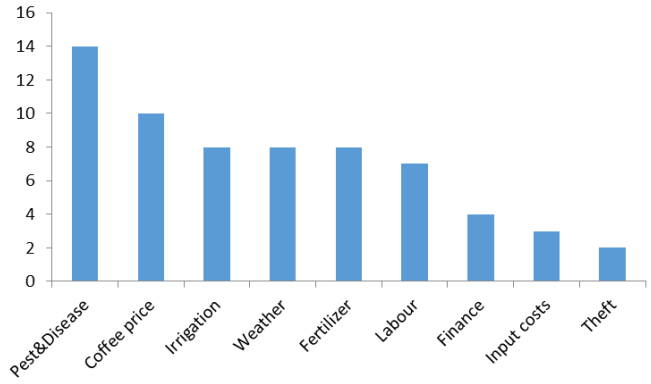


Figure 10-9: Frequency of production problems mentioned during interviews of 25 farmers in Cu M'gar (Vietnam)
Source: Baker (2012)

Besides the farmers, local expert organisations such as DARD[28] and WASI[29] were consulted to triangulate the farmers' feedbacks. Overall, they confirmed the statements made by the farmers and mentioned that water scarcity is a key worry which might be overcome if rain seasons become longer. The experts agreed that only few adaptation options exist and that little data was collected to identify the true extend of the problem of climate change. One

[28] Department for Agriculture and Rural Development
[29] Western Highlands Agriculture and Forestry Research Institute

major difference from farmers' opinions concerned the quality loss through drying difficulties which was found to be more severe by the experts than by the small holders. In summary, both groups contributed their local expertise to the project and generally backed the information from NRI and CIAT in the knowledge absorption step. They all concluded that the problem of climate change has been becoming more aware amongst the farmers, but lacks public or private initiatives to deal with the risks associated thereto (Haggar 2011). As the project has reached its final phase and terminates September 2013, the developed 'toolbox' that enables adaptation of farmers is currently tested in the four pilot countries. Progress reports about the practicability of the tool box and impacts of the implementation of selected adaptation strategies are expected due to be published by the end of 2013.

10.4.3 Contribution of Ecom

Ecom was one of the latest partners who joined the project and contributed with the traders' perspective to the project. The organisation was mainly involved in the knowledge transformation and utilization steps and took a sceptical viewpoint on awareness rising and how to collaborate with other SN agents in adaptation activities. Ecom takes the position that more information about the risks associated with climate change must be made available to the sector as the current level of awareness is perceived to be relatively low. Even though everybody talks about climate change, roasters were able to maintain supply of their desired species in recent years. However, Ecom is aware of the future projections and demands for more awareness rising amongst the SN agents and particularly the farmers, and for more planning ahead for financial investments. It therefore argued that the focus should be more on adaptation rather than on mitigation, despite the fact that the later topic has recently been pursued by the standard organisations with their certification schemes and carbon measuring approaches. Ecom also admitted that it has difficulties in distinguishing between climate change adaptation and good agricultural practices and therefore aims to clarify the terminology on adaptation across the coffee business: *"I do not know the right words, but what the farmers should be doing [is good agricultural practices] whether the climate is changing or not"* (interviewee M).

The PPP project is understood as valuable platform to exchange information about climate change, but Ecom finds it difficult to collaborate with direct competitors such as the Neumann group. Currently, Ecom is very passive in the project and argued that fewer pre-competitive elements could be identified whereas competitive elements in adaptation will rise. Interviewee (M) made clear that *"one thing that is competitive that we do not want to share with our competitors is geography".* The company fears that made investments in the coffee growing

areas could be benefited and stolen by competitors without making any financial contribution. The problem is not perceived to be that big as long as small projects are set up, but will become serious at larger scale if huge investments are made. For that reason, Ecom contributed two main issues to the knowledge utilization step. First, adaptation to climate change should not restrict competition. And second, clear rules are required for the pre-competitive elements in collaborative activities concerning climate change. Interviewee (M) argued that *"there has to be some kind of 'Gentlemen's Agreement' to not poach each other's business"* and to prejudice the important and long developed relationships between traders and farmers.

In summary, Ecom has been very critical about the project, but contributed the topics awareness rising and pre-competitive versus competitive activities to the knowledge transformation and utilization step. As the trading business is very competitive in nature, Ecom finds it difficult to collaborative with market rivals and therefore has not been initiating adaptation projects so far, even though the organisation understands adaptation of the coffee sector as vital part of its business.

10.4.4 Contribution of Tchibo and Paulig

Tchibo was one of the initiators of the project and mainly contributed to the knowledge transformation and utilization steps. One of Tchibo's key reasons to take part in the project is its commitment to pre-competitive collaboration on climate change-related issues. The company also benefits from the community approach that helps Tchibo to reach its target of 100 per cent supply of sustainably grown coffee. The organisation made a significant financial investment into the project and presented the roasters' needs and ideas for SC adaptation. As the Neumann Group is strongly involved in the project and traders view adaptation critically concerning its pre-competitive status, Tchibo steered the project into a direction in which the results can be generally accepted and do not fulfil a purpose for selected project partners. Finally, Tchibo pushed the project partners to develop a tool that can be scaled up across the sector (top down approach), but at the same time integrates extension services, scientists, and most importantly farmers (bottom-up contribution). Interviewee (J) argued that *"if we cannot please 1,000 or 5,000 farmers, we cannot please 25 million smallholders".* In summary, Tchibo put money into the project and contributed with expertise on the sector wide requirements for an adaptation framework. Particularly interviewee (J) was strongly involved in the discussions and ensured that the created knowledge base was transformed into an easy to access and worldwide applicable toolbox.

In comparison to Tchibo, Paulig is a much smaller roaster and collaborated via the 'International Coffee Partners' (ICP)-Initiative with the 'Coffee & Climate' project. Paulig aimed to participate in a long-term project that increases the professionalism in coffee cultivation and was involved in the knowledge transformation step. But unlike Tchibo, the company mainly obtained information about the sector wide activities on adaptation, rather than contributing with own knowledge and concepts. Due to its smaller size, Paulig grasped the opportunity to join the project and to benefit from collaborative funding and resource sharing. The knowledge exchange with other organisations enabled Paulig access to sector wide adaption projects and allowed for learning about potential risks and opportunities associated with climate change. In summary, Paulig is one of the smaller project partners and mostly absorbs knowledge from the project to start a new organisational learning cycle. It contributed little financial support and highlighted the problems smaller roasters face in securing supplies in times of climate change.

10.4.5 Contribution of Neumann Foundation and GIZ

Like in the previous two presented projects, GIZ played the role of the public partner in the PPP project and ensured to keep with the publishing rules and neutral leadership. Moreover, it contributed local knowledge from its on the ground staff and ca. half of the funding. The Neumann group brought into the project its foundation (HRNS) and the consulting subsidiary EDE. In cooperation with the scientist Peter Baker, EDE Vietnam conducted the field research (interviews with farmers and local experts) and contributed with its organisational knowledge of the impacts of climate change to propose the following activities that might facilitate adaptation in Vietnam (Baker 2012):

- **Meteorological information** (precipitation, temperatures, groundwater levels, and soil pH measures) is required at a more precise level and should be disseminated throughout the farmers. Meteorologists from local universities might provide the data to determine the level of exposure to the risks associated with climate change.
- **Land cover, land use, effects of climate change on hydrology** should be explored further and illustrated in maps to discuss opportunities for adaptation.
- **Organising farmers:** It is very important to engender greater self-organization by farmers and to confront them with the problems they face. This approach is consistent with the 'Coffee & Climate' perspective that adaptation tools should be applicable at larger scale than at the single farm unit. Such community-based, bottom-up adaptation approach is also promoted by CARE International (2012) and CGIAR (Sova *et al.* 2012), for example.

- **Experimentation and tool development with farmer organisations:** the focus should be on dealing with insufficient water supply during the dry seasons, soil nutrition, root depth, pH analysis, pest and disease management, landslide protection, and irregular rainfall leading to drying difficulties. As farmers are over-watering their plantations, field experiments for improved water supply should be carried out.

In summary, the Neumann foundation and GIZ were strongly involved in the design of the 'Coffee & Climate' tool that enables farmers to assess their vulnerability and offers appropriate adaptation strategies. Derived from own on the ground observations, multiple interviews with farmers and local experts, the Neumann foundation in cooperation with Peter Baker concluded on a number of activities to be integrated in the tool box as part of the knowledge utilization step. Similarly to SMS in the Sangana PPP, HRNS' subsidiary EDE bridged between traders, roasters, and farmers, and has been assisting the small holders with the implementation of the developed toolbox.

10.4.6 The Coffee & Climate toolbox

"The 'Coffee & Climate' toolbox is a compilation of guidelines, training materials and other didactic material to inform, capacitate and empower farmers to cope with and adapt to climate change. It addresses the lack of systematically documented information and shared knowledge on good adaptation and mitigation practices in the coffee sector. The main purpose is to collect, evaluate, enrich and further develop practices and experiences from the field, and to initiate a collaborative and global learning process" (Coffee & Climate 2013). The toolbox is a result of the absorbed and transformed knowledge of climate and presented as part of the knowledge utilization step in the inter-organisational learning cycle. As illustrated in
Figure 10-10, the tool is accessible via a web-based platform and comprises 5 criteria to select from (climatic hazard, countries, tool type, coffee variety, and purpose). Each criterion encompasses several options such as drought, frost, rain, temperature, and wind for 'climatic hazard', for example.

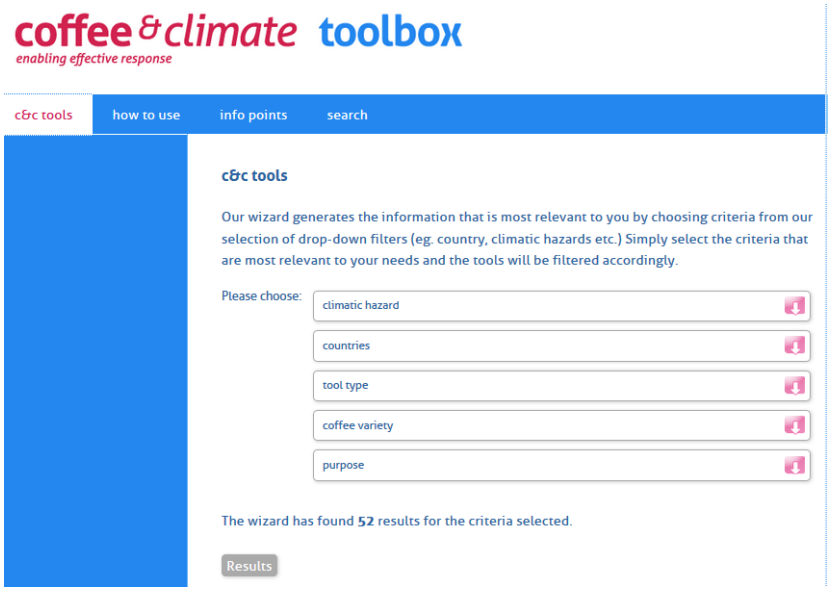


Figure 10-10: Coffee & Climate toolbox
Source: Coffee & Climate (2013)

In total, 52 adaptation measures were developed from which the farmers can select dependent on the choices from the 5 key criteria. Given the exemplified climate risk of drought ('climatic hazard') in Vietnam ('countries'), a total number of 5 adaptation measures were determined to make the farms ('tool type') that produce Robusta coffee ('coffee variety') more resilient ('purpose') to climate change as shown in Figure 10-11.

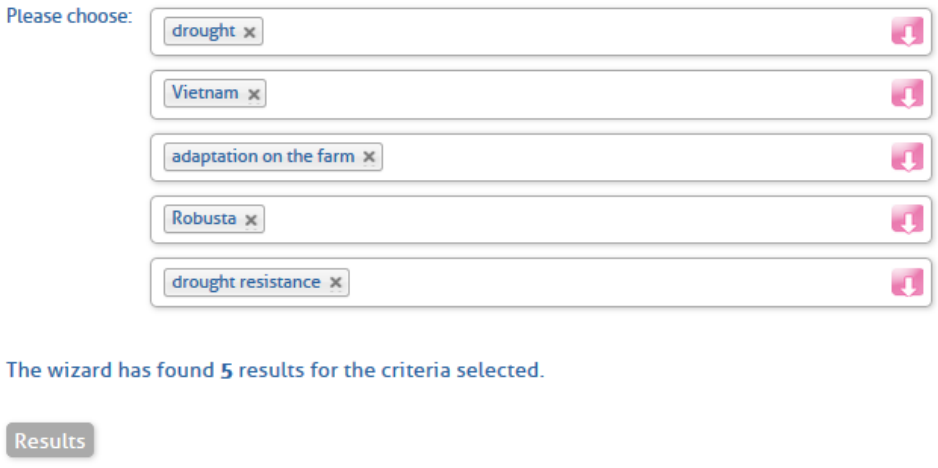


Figure 10-11: Exemplified application of the C&C toolbox
Source: Coffee and Climate (2013)

As a result of the selected filter, the proposed five adaptation measures include (Coffee & Climate 2013):

1) **Weed Selector (Soil Moisture Retaining – Live Cover):** To reduce loss of soil moisture during the dry season, the process consists of a horizontal wick of industrial (unrefined) cotton fed by a reservoir of glyphosate that drips by gravity onto the wick, which is passed about 20 to 30cms above the ground between coffee trees to selectively touch tall, fast-growing graminaceous weeds and thereby eventually select for slow growing ground-covering 'noble' weeds that compete relatively little with the coffee. After time, the cover crop becomes so good that weeding with the weed wiper will become increasingly infrequent. The work is not onerous, and at low cost in comparison to conventional weeding and mulching.
2) **Transplanting Experiments to Promote Resilient Plants:** To give coffee trees a better start after planting out. Encourages strong deep rooting and a good support for the first few weeks post-planting out. This practice is easy to apply and has a medium to high adaptation effect as it should be used prior to 'Farmer Field and Training Schools' to scale up the implementation
3) **Soil Moisture Retention Tool – Live Cover to Mulch (Crotolaria):** To reduce loss of soil moisture during the dry season, a cover crop in between coffee rows should be grown. Cut down regularly and spread over the ground to retain soil moisture and protect superficial coffee roots. As the cut material decomposes during the wet season, fragments will become incorporated into the soil, improving soil structure and further improving water retention properties of the soil. Additional benefits are protection against erosions and against strong winds for young tress. On the down side, cut material could present a fire risk under intense dry conditions and problems with pest and diseases might increase.
4) **Rainwater Harvesting:** Collection of rain water during the wet season for use in the dry season. An obvious way to survive increasing drought is to increase water storage facilities, either at the farm level or at the community or landscape level; water tanks to catch run-off during wet season. Calculations show that a farmer will need to store ca. 1600 m^3 water for Robusta irrigation. This adaptation measure is relatively easy to install and is highly effective to improve productivity at farm level.
5) **Drip Irrigation Tool:** Introduce small scale drip irrigation to farmers to reduce the impact of drought with only minimal water use. In areas with extensive and lengthening dry seasons, coffee support institutes should be considering the

potentialities of drip irrigation. Even though the drip irrigation is a technical advanced concept, it is a well-known technique and works if farmers are trained adequately.

In summary, the 'Coffee & Climate' toolbox is an easy to use framework and can be applied to all coffee growing regions worldwide. Dependent on the identified climate risk, localised adaptation measures are recommended and could be implemented at farm level with the support of technical staff from organisations such as SMS, EDE, and GIZ. However, some adaptation measures are still in the concept phase and have not yet been pilot tested and analysed concerning their adaptation effectiveness. To overcome this data gap, the toolbox was officially launched at the 10th African Fine Coffee Conference (AFCC&E 10) in Kampala, Uganda on February 16th 2013 to attract more SN agents to participate in the testing and implementation phase.

10.4.7 Inter-organisational learning of the Coffee & Climate project

The 'Coffee & Climate' PPP is the third and most advanced example for inter-organisational learning as illustrated in Figure 10-12. In a pre-competitive environment, four pilot regions and a number of global and local research institutes contributed observations and future projections of climate change. Driven by a joined effort, roasters and traders facilitated the development of a toolbox that can be accessed globally and that enables farmers and advisory services to implement adaptation measures according to the local risks associated with climate change. The web-platform concept facilitates knowledge transformation as successful examples of adaptation and new research findings can be shared and applied in other regions as well. Finally, the collaborate approach and large scope of the project brings together multiple SN agents and provides a systematic adaptation tool to be used beyond the formal end of the project in September 2013. Dependent on the organisational strengths, each SN agent can either contribute new practitioner and scientific knowledge, participate in the discussions to further develop the toolbox, publish examples for successful adaptation, and report difficulties during the implementation of the proposed adaptation measures.

SN Agents	*Representing*	*Four Phases of the Inter-Organisational Learning Cycle*			
		1. Knowledge absorption	2. Knowledge transformation	3. Knowledge Utilization	4. Adaptation
CIAT	*Scientists*	General overview of the future climate; scientific projections of climate conditions by 2020 and 2050, development of coffee growing suitability maps; decline up to 50%; more seasonality in rain and drought		Coffee & Climate Toolbox	
NRI	*Scientists*	General overview of the future climate; scientific projections of climate conditions by 2020 and 2050	Proposition of seven adaptation strategies to be implemented in Vietnam		
Smallholder farmers/ DARD/ WASI	*Farmers/ Local experts*	Observations and experiences of the impacts of climate change on the coffee growing process; suffering from plantlet pest and diseases, over irrigation leading to scarcity of water, extreme weather, changes in rain and dry seasons. Decline in coffee production by ca. 20% between 2010/11 and 2011/12.			Application of the developed 'tool box', currently tested by the farmers, but no concrete progress reports available; reports expected due to be published by end of 2013
Neumann Foundation/ GIZ	*Implementers*		GIZ represented the public partner in the PPP project and put in significant funding; contributing with first-hand knowledge of the impacts of CC. Neutral organisation that co-ordinated the different interests of all SC tiers. NF contributed solution approaches for individual tools (insufficient water supply, soil nutrition, root depth, pH analysis, pest and disease management, landslide protection, irrigation, and irregular rainfall leading to drying difficulties). NF via EDE assisted during the field testing of the tool box.		
Ecom	*Traders*		Emphasised strongly on collaborative activeties to raise awareness of climate change; requested clear rules for collaborative projects to distinguish between competitive and pre-competitive elements.		
Tchibo	*Roasters*		Represented the roasters position on CC adaptation that flows into the development of the toolbox. Emphasised strongly a pre-competitive approach on adaptation. Driving force of sector collaboration on adaptation as Tchibo is exposed to CC due to its 100% Arabica sourcing strategy.		
Paulig	*Roasters*			Contributed perspective of smaller roasters, mainly absorbed knowledge from the transformation step in the IOL-cycle to start a new OLC-cycle.	

Figure 10-12: Inter-organisational learning of the Coffee & Climate project (Vietnam case)

10.5 The IDH coffee programme

Despite the fact, that the three presented climate-related PPP projects (AdapCC, Sangana, and Coffee & Climate) proved to be successful in learning and adaptation, predominantly large coffee roasters (e.g. DE Master Blenders 1753; Mondelez International, Nestlé, and Tchibo, etc…) have recently begun to request for a global and sector-wide collaborative approach. Similar requests from other agricultural businesses such as in tea and cocoa resulted in the implementation of the IDH programme. The IDH programme was initiated as public-private-partnership to emphasis on sectoral analyses, pilot studies and reviews of agricultural practices, business strategies, certification methods, and financial mechanisms, that go beyond considerably small projects with selected partners in different agricultural businesses. For the coffee sector, the sub programme, 'Sustainable Coffee Programme (SCP)', was established as "*it will be increasingly difficult to meet the growing demand for sustainably grown coffee. Therefore, the need to address the sustainability issues in the coffee sector on a much larger scale and in a pre-competitive way is evident*" (de Vries 2013). The SCP will operate between 2011 and 2015 and aims to promote sustainable coffee production in a pre-competitive manner to make coffee farmers more resilient in an ever-changing market. The ambition is to increase sustainable green coffee sales from currently 8 to 25 per cent by 2015 globally by moving beyond the use of standards and labels and creating an overarching, holistic strategy for environmental sustainability and climate change adaptation. As the SCP differentiates from other small-scale projects, the analysis on inter-organisational learning focuses on the structures and processes to facilitate learning about climate change across the entire sector. An interview was conducted with the 'Senior Programme Manager Coffee' (interviewee V) to reveal how the IDH programme/Sustainable coffee programme carries out inter-organisational learning.

10.5.1 Role in the coffee supply network

To structure the global activities with currently 70 multinational companies that work as private partners in the sustainable coffee programme, a steering committee was implemented to determine the programme's strategy and to decide on possible field projects in the seven focus countries (Brazil, Colombia, Ethiopia, Indonesia, Peru, Uganda, and Vietnam). The steering committee comprises representatives from four large roasters (DE Master Blenders 1753; Mondelez International, Nestlé, and Tchibo) and from the public partners of the PPP programme (The Royal Dutch Coffee and Tea Association (KNVKT); European Coffee Foundation (ECF); GIZ; and WWF). The committee meets ca. every six weeks and decides the spending of the 10 million Euro budget until the end of 2015. The advantage of the SCP is its neutral position in the supply network as it is neither government nor fully private driven. The

programme aims to get a critical mass in the market to develop a common approach towards the risks associated with climate change. As independent organisation, it can steer meetings and sector-wide approaches without being suspected for taking a competitive advantage. It also watches out that no legal charges ensure regarding antitrust laws and other governmental regulations in the participating countries. However, as organisation without relevance for the market, the decision making process is difficult. Interviewee (V) admitted that the programme has not produced much yet and is way behind its schedule as a lot of meetings with coffee stakeholders were needed to define the role of the programme. Whereas roasters asked to set up collaborative structures and processes quickly, traders have been remaining in their competitive mode and excluded themselves from the programme and steering committee. Yet, as part of the field activities international and local traders will be involved at the farm level as any programme initiative interacts with the relationship between small holders and the trade. Another difficulty revealed from the relatively little knowledge of IDH managers about sector specific climate risks. The interviewee claimed not to be an expert about climate change and rather views herself in a moderating role who orchestrates the different coffee SN agents.

In turn, SCP has a closer working relationship with the 'Coffee & Climate' project. In order to make an impact across the sector and at the farm level, SCP aims to provide a starter kit for farmers comprising techniques to enable adaptation. For that reason, SCP sub-contracted coffee experts to consult on climate change adaptation (e.g. Duncan Pollard from WWF, etc…), integrated the Risk and Opportunity Assessment (ROA) from the 'AdapCC' project, and recently signed a Memorandum of Understanding to use the toolbox from the 'Coffee & Climate' project. The co-operation agreement is supposed to translate into national adaptation programmes in some of the 'Coffee & Climate' focus countries and Ethiopia. It aims to develop and test the toolbox further, increase the efforts to collaborate with local administrations and governments, and to scale up the adaptation tool to a larger audience of farmers. Based on the information obtained from the 'Coffee & Climate' project, six important areas for SCP field projects have been identified: **1. Quality** (verification/certification by the standards); **2. Productivity** (access to inputs such as fertilizers, small equipment, chemicals, and improved planting material); **3. Professionalization of Farmers and Farmer Organisations** (involvement of farmers as active participants or beneficiaries, development of farmer organisations); **4. Extension systems and capacity building** (building capacity of local extension services to work with standards systems); **5. Financing** (financial mechanisms for credit to farmers); **6. Coordination and Alignment** (involvement of government and existing initiatives; coordination with direct competitors on pre-competitive issues). Moreover, field activities may also relate

to opportunities for crop diversification and youth involvement. In comparison to the previous projects, the programme not only integrates the farmers into sustainability issues, but also strongly approaches local administrations and non-governmental organisations to reach a wider body of coffee stakeholders and farmers. So far, the SCP carries out two field operations in Ethiopia and Uganda even though their focus is on increased market access and export opportunities for farmers instead of dealing primarily with adaptation issues (van der Put 2013).

10.5.2 Collaboration with 4C Association

Even though SCP does not fund certification and does not support a particular standard, the platform concept of 4C might preferably be used to disseminate the programme results directly to the coffee stakeholders. This position is supported by the large coffee roasters that would like to see 4C as the home of the coffee programme after SCP terminates in 2015. *"4C has a lot of experience in how to get things moving, who the different players are, and they also provide a lot of advice on navigating with different politics, [as] in IDH we are not coffee sector specialists"* (interviewee V). However, the interviewee also referred to the present re-structuring process at 4C and the related difficulties. She argued that currently double structures might exist between 4C and SCP: *"Ideally, people would not have come to IDH, they would have gone to 4C instead […]. If 4C had been what people had created it to be, then we would not be needed".* Moreover, the interviewee admitted that she is not really familiar with the activities the standards have been carrying out and pointed out that standard alignment with the 'Sustainable Coffee Programme' is top on the To-Do-List to make use of their networks and reach out more farmers.

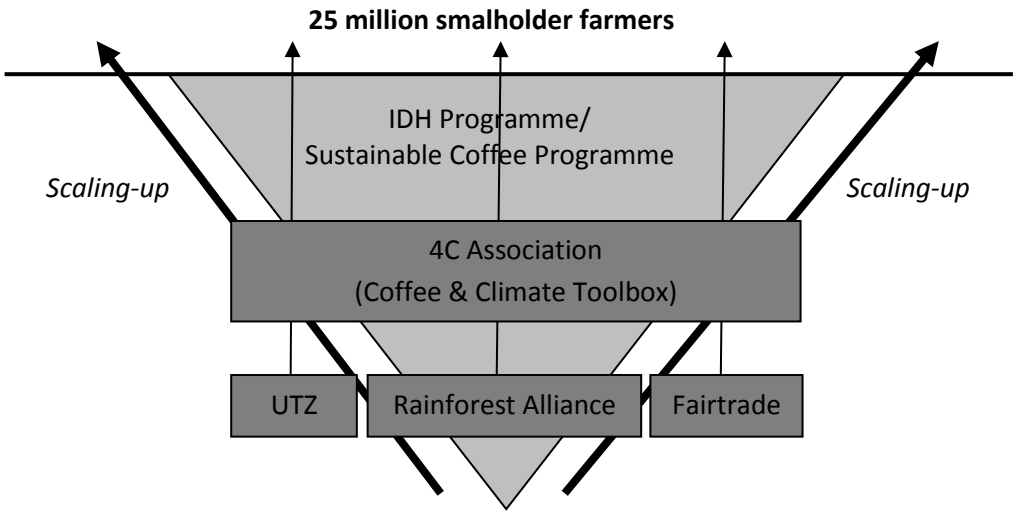


Figure 10-13: Scaling up-function of the Sustainable Coffee Programme

As shown in Figure 10-13, the SCP has also a scaling-up function by aligning differently developed adaptation approaches and distributing them to the larger farmer community. The IDH programme facilitates knowledge transformation across the coffee sector by temporarily taking over 4C's platform role and orchestrating climate related activities with all core and supporting SN agents. As part of inter-organisational learning, the findings from previous projects are integrated in the discussions to develop a common approach that deals with climate-related risks. Moreover, the neutral leadership position of SCP enforces the pre-competitive working environment and makes it easier for coffee stakeholders to join the programme. Even though traders and standards are not primary contributors to the initiative and part of the steering committee, they will also be involved in the implementation procedures in the focus countries.

In summary, the IDH programme follows the concept of a public-private-partnerships as a pre-competitive initiative. With the sub-programme 'Sustainable Coffee Programme' it aims to develop a global SC approach in response to the risks associated with climate change in the coffee sector. The collaborative approach differentiates from other projects in scale and scope as large roasters representing a third of the market have become partners in the programme. Being neutral to market players, SCP collaborates with 4C to disseminate the findings and to reach out further coffee stakeholders. Yet, SCP was trapped in intense discussions to align different interests and has only recently begun to integrate findings from previous projects such as 'Coffee & Climate' and to start the implementation process in the focus regions. The analysis of inter-organisational learning remains difficult as SCP builds up on previous work on adaptation and uses its own experiences and strengths to lobby with governments and develop national adaptation plan. Accordingly, SCP scales-up the already developed adaptation concepts and raises awareness amongst governments and supporting SN agents. However, so far SCP mainly carried out the first three steps in the learning process, but lacks concrete examples in which the developed understanding of climate risk has turned into actual adaptation of the supply network. The assessment whether the SCP might become an example for successful inter-organisational learning at a global scale can only finally be made after the termination of the programme in 2015. Until now, the initiative brought together big market players as well as non-governmental organisations such as GIZ and ECF which increases the chances to actually have an impact on the sector and to reach out more farmers to be prepared for adaptation to climate change.

10.6 Assessment of CASN factors

This section analyses how the internal mechanisms (*Agents, Network connectivity, Dimensionality,* and *Self-Organization/Emergence*) in a 'Complex Adaptive Supply Network' influenced the adaptation process to climate change in the four investigated cases of inter-organisational learning.

Agents

The investigation of the coffee business identified a worldwide supply network consisting of core and supporting agents. As described in literature, all agents shape the system's norms, behavioural rules, structures, and strategies. The four examples of inter-organisational learning revealed the discussions and approaches for the creation of adaptation tools that can be applied globally and verified by the supporting standards (*norms*). As adaptation is a relatively young topic, *behavioural rules* predominantly address financial matters. All agents agreed that farmers are unable to finance adaptation measures, but also complained about the absence of a sector wide settlement of who is putting money into what activities without being exposed to competitive disadvantages. Particularly the traders are very sensitive to the discussion on competitive vs. pre-competitive elements in a collaborative approach for adaptation and therefore demand for more clear regulations throughout the sector. *Structures* and *strategies* that facilitate adaptation are currently developed. Agents with different functions collaborated in a number of small scale projects to exchange ideas, to test frameworks for adaptation with farmers, and eventually develop suitable structures and strategies for adaptation that can be applied to the global supply network. This process also refers to the alignment of different business positions of the involved agents (Lee 2004). The investigation revealed that the coffee supply network lacks alignment in the overall commitment for collaboration in a pre-competitive environment. Whereas roasters, scientists, and implementers (GIZ and foundations) clearly see the need to work together on adaptation matters, the traders persist in the competitive mode and are not entirely willing to collaborative with market rivals. The standards perceive the need for alignment (e.g. Rainforest Alliance took part in the Lausanne workshop organised by Ecom to discuss climate-related activities), but have also begun to develop own adaptation tools that can be added to their existing certification schemes, respectively. Yet, progress in the alignment of different adaptation tools has been found as most of the standards have become members of the 4C organisation. Transforming from a pure baseline standard to a platform concept that hosts sector wide knowledge of climate change, 4C could be capable to align different interests and conclude on a single, globally accepted adaptation framework. Such outcome might be built on

the toolbox from the 'Coffee & Climate' project and its enhancement as part of the IDH programme.

In summary, the coffee supply network consists of multiple tiers and has very complex structures to process coffee from the farm level to the end-consumers. At the small-scale project level, successful examples for adaptation in some regions have been revealed as the involved stakeholders agreed on a common approach to enable adaptation. At the network level, it was found to be difficult to align the different interests along the SC and to conclude on a mutually agreed adaptation approach in response to the risks associated with climate change. This problem might be caused by the lack of a focal company or dominating tier within the supply network as roaster, traders, and partially farmers have strong market power. In conclusion, the lack of alignment amongst the agents on mutual norms, behavioural rules, structures, and strategies indicates a reason for the difficulties of the coffee supply network to adapt to climate change.

Network connectivity

Measuring the number of links between the organisations within the coffee supply network, the investigated case is highly complex. The feature to have millions of small holders who supply the raw material (green coffee), a relative small number of international traders and roasters, and millions of end-consumers makes inter-organisational learning very difficult. On the one hand, the investigation on organisational learning revealed that agents are unable to be very strong in all four steps and require interactions with other organisations to understand climate risk and adapt to it. On the other hand, inter-organisational learning proved to be successful at a small project scale in selected regions, but revealed to be difficult for the worldwide supply network. The number of internal links seems to be too large to quickly develop and implement adaptation measures that make the entire coffee business adaptable to climate change. The difficulties increase as the number of weak links, i.e. those who are most vulnerable to climate change, are the millions of small holder farmers. That makes it increasingly challenging as this network structure prevents the leading agents from rapidly reaching out the weakest links and implement adaptation measures to increase the resilience overall (Tilebein 2006). Considering the concepts of horizontal and vertical knowledge creation in networks (Pena 2002), the research revealed that knowledge creation predominantly occurs as a result of vertical interactions in the coffee business. Despite the fact that roasters collaborate to easier push forward their ideas on adaptation, and farmers become more organised in local communities to simplify knowledge transformation and utilization, the

investigation of the inter-organisational learning projects clearly indicated a vertical flow of knowledge. The learning cycle could only be completed if agents from different tiers and with different roles collaborated in all four steps. The vertical approach closed the gaps in agents' organisational learning by ingesting specific knowledge from other tiers and supporting activities. Finally, connectivity also relates to the co-evolutionary dynamics between the network and the environment (Tilebein 2006). The field research revealed information that confirms the theory. The interviewees argued that adaptation activities might have a mitigating effect as a reduction in the use of fertilizers will also cut carbon emissions, for example. Accordingly, there is clear evidence found for a co-evolutionary process between the coffee supply network and its environment even though the adaptation measures might contribute only little to the overall and global mitigation efforts to climate change.

In summary, literature suggests that the more links within a network, the more difficult learning might become. The investigated case showed that the large number of agents in the global coffee network is a challenge for rapid learning. However, vertical knowledge creation to understand the impacts and future projections of climate change requires the collaboration between multiple stakeholders such as scientists, local implementation services, and neutral governmental organisations (GIZ). As learning also comprises adaptation which mainly takes part at the farm level, even more organisations must be involved to reach out the small holder communities with 25 million people. Therefore, it is reasonable to conclude on the trade-off between the goal to simplify the network for quicker learning, and the need for the involvement of thousands of (local) organisations to scale up adaptation across the millions of farmers.

Dimensionality

Dimensionality addresses the trade-off between the organisational level of autonomy and need for overall rules throughout the network to maintain its manageability (Choi *et al.* 2000; Tilebein 2006). The field research revealed evidence for the suggestion in theory that closer collaboration will result in better communication, and lead to efficient and effective adaptation (Choi *et al.* 2001). Most of the interviewed SN agents argued for the need of a common approach to adapt the network to climate change and demanded for clear action rules between the stakeholders. The analysis of inter-organisational learning clarified that closer working relationships enable a network to learn and adapt to climate change. There was no evidence found that too close links may reduce the diversity of ideas (Desai 2010). Rather, loose connections are likely to prevent the network from developing a global toolbox for adaptation as knowledge absorption might be incomplete due to missing information from

scientists, practitioners, and other supporting agents. Also, knowledge transformation will become difficult if stakeholders are not committed to contribute to common approaches. Coffee traders, for example, are unclear about their role in a collaborative approach for adaptation as a result of their competitive market habits. As a consequence, this important tier in the supply network is currently only integrated occasionally in sector wide initiatives such as in the case of Ecom and Neumann in the 'Coffee & Climate' project. However, both organisations have excluded themselves from the larger 'IDH/Sustainable Coffee Programme' and therefore make it difficult for the network to adapt as some of the core agents are not closely linked to other tiers. For that reason, neutral leaders such as IDH can orchestrate the various interests and create a pre-competitive environment with strong links between the SN agents that may also attract the trade to join the initiative in the future. The research also revealed evidence for the theory that agents in such a pre-competitive working environment are willing to share their tacit knowledge (Stonehouse and Pemberton 1994; Holmqvist 1999; and Pena 2002). The concept of a PPP project with a public and neutral partner (IDH, GIZ) proved to be successful with clear rules for financial contributions, and the sharing of tacit and explicit knowledge.

In summary, the investigation of the inter-organisational learning projects showed that close working relationships facilitated learning at the network level. At small scale projects, public stakeholders ensured accepted actions rules and enabled access to tacit and explicit knowledge in a pre-competitive environment. However, the challenge is to scale-up the findings to the multi-million smallholder farmers. It is reasonable to conclude that at the global scale the links between stakeholders might not be as close as in smaller projects. Moreover, the level of collaboration is likely to be different amongst the agents. At the moment, roasters, extension services on the ground, scientists, public organisations, and farmers work together in adaptation initiatives. But so far, they have not convinced the trade to work more closely with other stakeholders, particularly as they are not willing to participate in horizontal knowledge creation between different traders. In conclusion, the coffee supply network requires strict action rules to maintain the manageability of the development and implementation of adaptation tools.

Self-organisation/emergence

The research revealed that the coffee supply network takes responsive actions to climate change, but did not generate new emergent structures and patterns without being externally imposed as suggested in literature. Evidence was found that trial projects and idea generation

were initiated bottom up as farmers contributed their needs and knowledge to the learning cycle. Confirming the theory by Espinosa and Porter (2011), the interviewed practitioners argued that farmers must be presented strong attractors for adaptation to change existing habits and to facilitate self-organisation amongst the farmer communities. In the case of the coffee supply network, improvements in agricultural practices will increase productivity and ultimately the livelihood of the small holders. Yet, the bottom-up processes are not very intense in the coffee business. All identified adaptation initiatives are top down driven by roasters and supporting agents. However, some interviewees argued that self-organisation at the farm level might become the key to scaling up adaptation measures. As it is likely that the network cannot reach every single farmer who is exposed to climate change, local trainings about the benefits for small holders increase the chances to disseminate the developed tools. In summary, climate-related initiatives within the coffee supply network are currently driven top down rather than bottom-up. Nevertheless, the research also revealed the difficulties to mainstream the ideas and developed approaches. A possible solution could be the 'train the trainers'-principle to facilitate self-organisation for adaptation directly in the growing countries.

10.7 Summary of inter-organisational learning

The investigation of the coffee supply network identified four specific cases of inter-organisational learning (AdapCC, Sangana PPP, Coffee & Climate, IDH Programme) and revealed their process structures and the flow of information and knowledge throughout the four steps of the network learning cycle. Proposition two (P2) that "*Networks do learn and adapt to climate change"* is verified as evidence was found that inter-organisational learning helps the organisations to strengthen and complete their learning cycles and facilitates the adaptation of the supply network to climate change as a whole. All four investigated cases show that inter-organisational learning happened as part of public-private-partnerships and involved representatives from all core and supporting agents. Networks learn in the sense that public organisations moderate the different stakeholder strengths and interests, and establish clear action rules which facilitate the sharing of tacit and explicit knowledge in a pre-competitive manner. Without the established climate-related projects, the coffee supply network would be unable to learn in a structured way and only physically process coffee from the farmers to the end consumer. As summarised in Table 10-5, the internal mechanisms (agents, network connectivity, dimensionality, and self-organisation) of the coffee supply network influence the learning capabilities. The investigation showed that an orchestrating function from outside the core SN agents might be best to scale up the different adaptation

approaches and ensure a pre-competitive environment with clear rules for financial and resource contribution.

CASN Factor	Coffee Supply Network
Agents	- Distinction between core agents (farmers, traders, roaster, (end-customers); and supporting agents (standards, scientists, implementers). - Agents shape norms (adaptation tools); behavioural rules (Public-Private-Partnership regulations; financing rules); and structures and strategies (under development; refers to scaling up concepts and permanent structures that go beyond temporary projects) - Alignment of agents' strategies towards adaptation is essential; otherwise too many different concepts, e.g. every standard (Fairtrade, 4C, UTZ, Rainforest Alliance) develops an own adaptation tool to be integrated into its existing verification scheme. These multiple approaches are unaligned and are difficult to scale-up to the global supply base.
Network connectivity	- A large number of internal links in the coffee supply network makes it highly complex. - Millions of farmers are exposed to climate change and need to adapt to the risks associated thereto. - Even though learning might be easier with fewer collaborating agents, more stakeholders can contribute tacit knowledge and disseminate the developed adaptation tools to the wider farmer community. - Learning predominantly occurs through vertical knowledge creation, i.e. between organisations from different tiers.
Dimensionality	- Close working relationships are needed as agents are unable to learn about climate change without external support. - Overall rules throughout the network are required to create a pre-competitive environment and eliminate the fear of suffering from competitive dis-advantages. Such rules are best created if a public partner is involved in the adaptation initiatives.
Self-organisation/Emergence	- Little bottom-up self-organisation throughout the network. Yet, trial projects to develop concepts (i.e. investigated projects) were set up. The results could then be integrated into a larger initiative (IDH programme). - Train the trainers-principle might be the key to disseminate the adaptation tools to the farmers and encourage them for more self-organisation if they experience the benefits.

Table 10-5: CASN factors in the coffee supply network

Chapter 11: Development of the network learning process

11.1 Introduction

This chapter discusses the research findings in the context of each research objective and aims to provide clear answers to each of the research questions. The first section addresses research objective 1, to examine the current learning processes in the coffee business related to climate change risk (RO1), and particularly gives an answer to the first research question (RQ1): What type of learning enables companies and networks to adapt to climate change risk? Section 11.3 discusses the second research objective (RO2), to develop a process model of network learning applicable to climate change. The learning process and model of network learning in the coffee business is presented in answer to research question two (RQ2). Finally, in Section 11.4 the enabling principles and mechanisms at the organisational and inter-organisational levels that facilitate the proposed network learning process (RQ3) are presented.

11.2 Learning processes in the coffee supply network

The literature review revealed that learning comprises 'understanding' and 'adaptation' and passes through a four step learning cycle that can be deployed at the organisational and inter-organisational levels. The research findings concerning knowledge absorption and transformation steps, within the organisational and inter-organisational learning cycle, indicate that the coffee supply network is highly exposed to climate change risk. As summarised in Table 11-1, evidence was found that suggests that all five climate risk factors impact directly and or indirectly on the SN agents. Farmers are highly exposed to direct impacts caused by changes in risk factors including water, ecosystem, and extreme weather, while agents further upstream in the supply chain suffer more from the indirect impacts such as the decline in coffee availability and increasing procurement costs.

Supply chain risk management was presented as a way of mitigating the risks associated with climate change and to increase the resilience of a supply network. Mitigation comprises approaches such as agility, alignment, and adaptation; the latter strategy was found particularly necessary to cope with the impacts of climate change. The investigation revealed that the 'knowledge utilization' and 'adaptation' steps in the learning cycle enable the development of adaptation measures and their actual implementation at the farm level. For the coffee supply network, adaptation measures include improvements in good agricultural practices such as better mulching, more efficient irrigation and planting of shade trees. Adaptation also includes the need for modern technical equipment such as solar dryers and considers the development of new coffee species that are more resilient to climate change.

Climate factors	Direct impacts	Indirect impacts	Risk Mitigation: Adaptation measures
Water	- **Unseasonal rainfall:** *uneven and unseasonal distribution of rain; rainfall within dry periods makes it difficult to dry coffee outside (e.g. in Mexico and Kenya).* - **Extreme rainfall:** *flooding of territories at lower altitudes (e.g. in Mexico).* - **Drop in groundwater:** *shortage of fresh water for irrigation (e.g. in Vietnam).*	Decline in the overall supply of the raw material 'green coffee'; rising coffee prices as a result of increasing demand; increased poverty amongst farmers	- Use solar drying systems - Improve wet milling practices - Terracing of farms to control infiltration and storage of rainwater/ Diversion of river/canals - Modernised pulping machinery consuming less water per area
Food	**Overall decline in coffee growing suitability:** *in all producing worldwide countries; suitability decreases at lower altitudes and increased at higher altitudes.*		Diversification in coffee species that are more robust to climate change
Ecosystems	- **Plagues, fungi, blight, and pests***: caused by too many clouds leading to lower temperatures and stronger moisture (up to 60% loss of harvest in some Mexican areas).* - **Soil damage:** *increase in temperatures leads to decreases in soil nutrition that results in reduced productivity; extreme rain causes soil wash and erosion.* - **Changes in tree flowering season:** *in Kenya, trees do not flower when they are supposed to.* - **Deforestation:** *increased number of forest fires caused by increasing temperatures (some regions in Mexico).*		- Use organic fertilizers - Planting of shade trees to create a micro-climate with higher temperatures - Re-planting of young trees - Abandon deforestation - Natural weeding to improve soil moisture
Extreme weather events	- **Hurricanes**: *Hurricane Stan (2005) destroyed a significant proportion of the harvest (up to 50%) in Latin America (particularly in Mexico and Guatemala). This happens more frequently and has become more severe.* - **Hailstorms and frost:** *unusually experienced in Kenya, causing tree injuries, (up to 60% loss of harvest in some Kenyan areas).* - **Extreme rain:** *annual rainfall falls within days (up to 60% loss of harvest in some Mexican areas).* - **Drought:** *some areas in Kenya suffer from minimal rainfall and prevent trees from growing coffee beans; loss of soil moisture.*		- Re-planting of young trees - Mulching to reduce evaporation and improve soil moisture - Planting of hedges to reduce wind and water damage
Rapid climate change	**Yet to happen – projected for the future, but currently no example**		- Increased co-investments of private agents - Increased public funding - Rising Awareness

Table 11-1: Summary of the direct and indirect impacts of climate change on the coffee supply network and the related risk mitigation measures

The investigation of the coffee business revealed that farmers absorb knowledge and are the entities that need to implement the adaptation measures. This is encouraging as direct impacts and adaptation measures primarily act at the farm level. However, farmers like all other interviewed organisations, only partially learn about climate change and are unable to adapt to the impacts of climate change independently. They have different strengths in the learning process and tend to focus either on understanding or adaptation, but none of the agents in the network completed the entire learning cycle. It is therefore reasonable to conclude that adaptation of the supply network is not a result of independent organisational learning, but requires a co-ordinated inter-organisational network learning approach.

	Context of learning	
Level of learner	**Organisational**	**Inter-organisational**
Organisation	Organisational learning of each SN agent; refers to Nonaka's (2004)spiral of knowledge creation	Inter-organisational projects such as AdapCC, Sangana PPP, and Coffee & Climate
Network	Organisations must implement the developed adaptation measures (network learning outcome) to increase the resilience of the coffee supply network as a whole.	National and international network learning programmes such as the IDH/Sustainable Coffee Programme

Table 11-2: Network learning in the coffee supply network
Source: adopted from Knight (2002)

The investigated inter-organisational pilot projects (e.g. AdapCC, Sangana PPP, Coffee & Climate) enabled the completion of the learning cycle and resulted in the adaptation of some, but not all parts of the supply network due to the limited scale and nature of these projects. Only an international learning programme, such as the IDH programme, enables the coffee supply network as a whole to learn about climate change risk, change existing processes and structures and thus adapt. This position is illustrated in the bottom right quadrant in Knight's (2002) learning matrix as shown in Table 11-2. Changes in the coffee network not only refer to changes in mental models and behaviour towards climate change as an outcome of network learning, but also require the practical implementation of adaptation measures at the farm level. For that reason, the outcome of network learning in the form of physical adaptation is also influenced by the performance of the implementing organisations. The interrelationship between local and global activities also addresses the theory of complex adaptive supply

network as coevolution will create general network characteristics (e.g. overall adaptation concepts, etc…) which then influence the way agents at local scale behave and adapt (e.g. the localised implementation of adaptation measures, etc…) (Nilsson and Gamelgaard 20012).

Development of a definition of supply network learning

Integrating the different findings from the case study, 'network learning' is proposed as the answer to the first research question (RQ1): What type of learning enables companies and networks to adapt to climate change risk? The research also confirms that the concept of network learning is an extension or a combination of three major themes: organisational learning; inter-organisational learning; and complexity in a (global) supply network. Each of these themes can be summarised as follows:

Organisational learning

Organisational learning is defined as a process of improving actions through the creation, integration and exploitation of knowledge (Fiol and Lyles 1985; Bierely *et al.* 2000; Senge 1990) which prepares the organisation for adaptation to a changing environment (Montuori 2000).

Inter-organisational learning

Inter-organisational learning can be defined as creating accelerated synergies between linked organisations through shared knowledge and competencies (Stonehouse and Pemberton 1999) to improve internal organisational learning through strengthening the external links with the network partners and integrating their skills and knowledge for the own benefit (Pena 2002).

Complex adaptive supply network

A complex adaptive supply network is a system of interconnected agents that as a group evolves and self-organises over time and that is flexible, proactive and responsive to a changing environment (Pathak *et al.* 2007; Nilsson 2003). The complexity in such as network can be described by the notion that no improvements can be made*" assuming ceteris paribus (all other things remaining the same), because many attributes are emergent properties that arise from the interacting components that make them up"* (Allen and Strathern 2003, p. 28).

Combining these three theories following the logic presented above, the following definition of supply network learning is proposed by the researcher:

> *"Network learning is an integrated and co-ordinated process of knowledge absorption, transformation and utilisation by network agents as a group which enables the network as a whole to adapt to a changing environment"*

Applying this definition to the coffee business, evidence for Fiol and Lyles' (1985) concept of 'higher and lower level learning' was found that facilitate *integration*, *co-ordination* and *preparation* throughout the supply network. Each can be described as follows:

'Higher and lower level learning' in the process of network learning in the coffee business

Higher level learning generally questions the current business paradigm and aims to change existing overall rules and norms rather than specific actions (Fiol and Lyles 1985). Higher level learning does not necessarily induce changes in physical operations, but mainly adapts the present structures and processes of an organisation and the network to respond sustainably to a changing environment. In the coffee supply network, higher level learning happens across all the tiers except the farm level as the small holder community lacks the ability to engage in this learning process. The remaining core and supporting agents are searching for a change in the current climate-related activities and looking for new investment opportunities, and adaptation strategies to help the farmers. As a result the adaptation of the present supply network structures, strategies and processes associated with higher level learning can then facilitate lower level learning throughout the farmer community.

Lower level learning aims to improve current operational practices without altering the nature of the activities. In the coffee supply network, the small holder community lacks the competences of higher level learning, but is the tier in the supply network that physically prepares the whole network for the impacts of climate change. As part of the adaptation step in the learning cycle, farmers use their lower level learning to implement the proposed adaptation measures including better irrigation, planting more disease resistant species, and using advanced farming technology. The farmer community very rarely questions the general nature of their agricultural practices as this would require higher level learning, e.g. there are currently very little thoughts about diversifying the production to a more climate-resistant crop than coffee.

The processes of higher and lower level learning were happening throughout the three collaborative projects on adaptation to climate change (AdapCC, Sangana PPP, Coffee &

Climate). The research showed that in all three cases, the organisations outside the farm level created temporary communication, financing and working structures and processes that enabled the collaborative development of new adaptation strategies for the pilot coffee production regions. As part of the higher level learning process, sector-wide adaptation of business initiatives such as the need to create an overall pre-competitive environment in the context of climate change, were proposed. In summary, collaborative higher level learning amongst core and supporting SN agents supports lower level learning of the farmers in the coffee supply network.

Scaling-up the learning process

In the coffee supply network, the proposed network learning process faces the particular challenge of integrating the large farmer community and disseminating the adaptation measures to the millions of small holders in the world's main coffee regions. For this reason, scaling-up the adaptation measures to the farmers becomes an essential part of the network learning process. A combination of top down and bottom-up management is required that can be related to the CASN factor 'dimensionality' which relates to the tension between organisational freedom and the manageability of complex supply networks (Choi *et al*. 2001). To facilitate the scaling-up process, top down initiatives from powerful SN agents, such as large roasters (e.g. Tchibo, Nestlé, etc..) have been promoting reforms of business practices and the implementation of new processes throughout the network to facilitate adaptation. Reaching out to the farmers, more collaboration in knowledge, resources, and financial investments is required to scale up the adaptation measures. To achieve this up-scaling, the IDH programme, for example, has been set up to steer and co-ordinate the network learning process with an increasing number of SN agents participating. It can reasonably be argued that only top down initiatives from big players in the coffee business can facilitate collaborative higher level learning and sustainably adapt the present processes at lower levels in the network.

Choi *et al.* (2001) argue for a certain level of autonomy that allows agents in a supply network to self-organise and to learn about a changing environment. In the case of the coffee supply network, farmers are weak in knowledge 'transformation' and 'utilization', but are the entities that have strong experiences in the impacts of climate change and must implement the appropriate adaptation measures. Therefore, farmer commitment to participate in network learning is vital. They must 'upload' their climate-related observations to the partnering tiers and must be willing to take on and practice the relevant adaptation measures. The commitment of small holders to participate in network learning also facilitates the self-

organising process as every farmer is likely to understand the practical benefits of the adaptation measures in the form of better quality and increased outcome of coffee production. On the basis of this favourable experience, the farmers might recommend adoption of the measures to other farming communities and thereby disseminating the improved agricultural practices. This process aligns with the theory by Espinosa and Porter (2011), whereby actions that have proven beneficial to some SN agents, attract other agents and consequently facilitate change and support the self-organising process.

In summary, the investigation of the coffee supply network reveals that learning at the organisational as well as inter-organisational level is necessary to enable adaptation of supply networks to climate change. Lower level learning at farm level and a collaborative approach to higher level learning throughout the remaining network tiers, appear to be very effective processes. Evidence of both levels of learning was revealed from the three adaptation projects, with higher level learning the more pronounced at the network scale. So far, however, no significant changes in the coffee business' structures and processes were identified. For that reason, top down initiatives from powerful roasters established the 'Sustainable Coffee Programme' to facilitate network learning, i.e. learning as a group, which is beneficial for the entire coffee business by mutually developing a global adaptation solution to climate change.

11.3 Model of network learning to climate change

This section presents a model of network learning based on the research findings and in response to the second research question (RQ2), i.e. 'What is the network learning process?' As illustrated in Figure 11-1 the proposed model adopts a spiral design, similar in concept to that used by Nonaka (2004), to model the overall process of network learning. Nonaka (2004) used a spiral to model the process of knowledge creation, whereas in this model is the researcher attempts to depict the process of network learning as revealed in the coffee network.

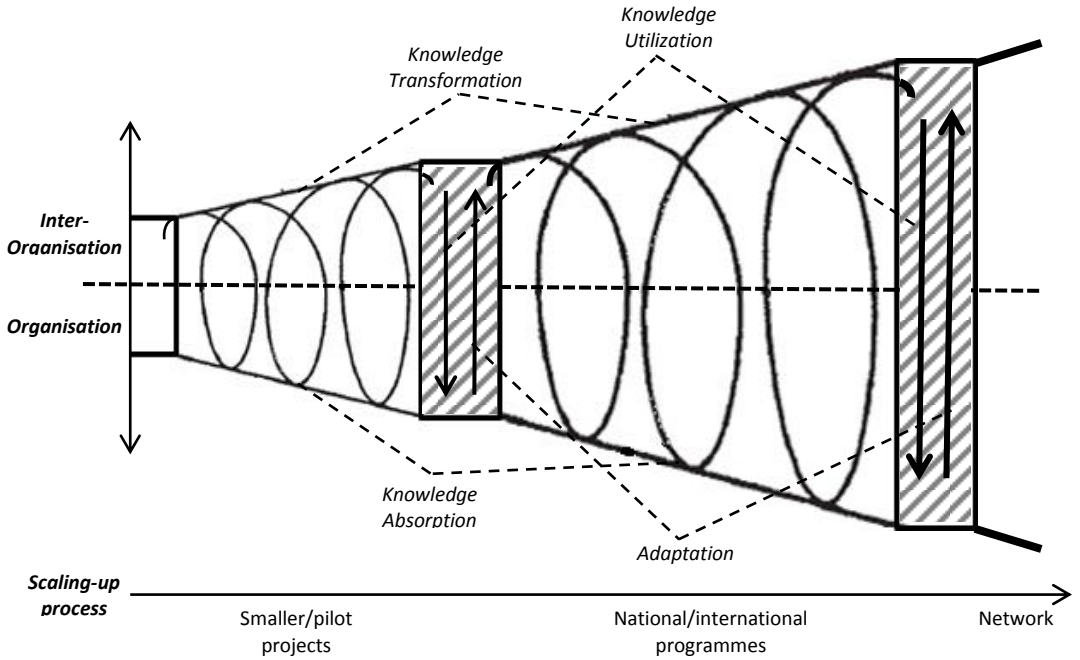


Figure 11-1: Spiral of network learning

The spiral design was chosen as it best illustrates the interactions between the three different and distinct elements in the network learning process. As network learning occurs for the benefit of the network as a whole rather than for single network members, the following features have been included in the proposed model of network learning:

1. The design integrates the proposed four learning steps (knowledge absorption, knowledge transformation, knowledge utilization, adaptation) which occur at different positions in the spiral. The field research revealed that some parts of the general learning process occur rather as a result of organisational learning and others as part of inter-organisational learning. Knowledge absorption and adaptation happen at the organisational level, whereas knowledge transformation and utilization are part of the inter-organisational aspects of network learning (Y-axis of the model). Each step can be summarised as follows:

   <u>Knowledge absorption</u>

   Organisations are the learning entities that need to first understand the business environment and absorb knowledge of those changes that may directly impact upon them, or the wider supply network. Absorption of knowledge of a changing environment therefore strongly relates to the organisation's capabilities in knowledge creation. Accordingly, the knowledge absorption step in the learning cycle corresponds with

Nonaka's (2004) spiral of organisational knowledge creation. The literature review clarified that individuals are the learning entities in an organisation (Simon 1991) and, in the case of inter-organisational activities, act as the interface with other organisations in the knowledge transformation step in the network learning process. In this way companies translate individually absorbed knowledge into organisational knowledge.

Knowledge transformation

As part of the second step, knowledge from different agents is transformed to create a mutual knowledge base. Inter-organisational communication and collaborative actions combine the knowledge and expertise of supply network agents to create a mutual knowledge base about the environmental changes that threaten the network. Knowledge transformation is therefore a platform for the exchange of data, information and knowledge.

Knowledge utilization

In the context of network learning, knowledge utilization refers to the collaborative development of strategies and activities with the aim to enable adaptation of the network. At the inter-organisational level organisations can contribute their ideas and local needs to the design of adaptation measures. To minimise the risk of the advice becoming too prescriptive, many different agents should be involved, particularly if the developed solutions are designed to be applied globally. It is also recommended that the agents who are exposed to a changing environment and who eventually need to implement the adaptation measures take part in the knowledge utilization step. Otherwise, these agents might not fully understand the purpose of the measures and not be totally committed to their implementation.

Adaptation

Adaptation addresses two different levels in a supply network. First, it refers to physical changes in operational routines that make organisations more resilient to climate risk. The improvements in day to day tasks can be viewed as the outcome of lower level learning in the network learning process. Second, as a result of higher level learning, the present business habits at the organisational and inter-organisational level must also be adapted to facilitate physical adaptation. In the coffee supply network, the physical adaptation is carried out by the farmers, whereas the structural adaptation of the supply network is performed by the remaining core and supporting organisations.

2. The two-sided open-ended spiral design illustrates a certain level of symmetry in the learning steps. The entire learning process can be passed through in both directions. For example, an organisation that participates in inter-organisational knowledge transformation and utilization may not only contribute knowledge of environmental changes and the development of appropriate adaptation measures, but may also absorb new knowledge from other agents that flows back into the organisational learning process.
3. The nature of the investigated network with its highly dispersed supply base and numerous organisations involved at different tiers and with different functions requires the network learning process to be carried out in a scaling-up process. Accordingly, the 'group of organisations' that learns varies at the different stages towards the network as a whole. Initially, only selected members of the supply network learn in inter-organisational pilot projects to keep the group manageable. Based on the pilot outcomes of network learning, further organisations can be added to the 'group' and develop changes in network practices and structures with the aim to adapt the network to climate change. As illustrated in Figure 11-1, the final learning step 'adaptation' is designed as bottom up arrow from the organisational to the inter-organisational level. This design element indicates that the learning outcome of pilot projects (adaptation) is the input for subsequent learning cycles in international programmes at a larger scale. The box design comprising knowledge utilization and adaptation is chosen as it illustrates the separation between the different stages in the spiral of network learning. Even though one network learning stage is terminated (e.g. at the project scale, etc…), it may take time to set up the next stage at a larger scale. Accordingly, the boxes include the adaptation step as a final activity in a learning process and symbolise that at the end of each scaling-up stage, some parts of the supply network have been adapted to a changing environment. This scaling-up process is similar to Knight and Pye's (2004; 2005) concept of 'episodes' of learning which refer to punctuations in the network learning process to analyse the learning outcomes and experiences so far. Such a stepping-up principles also allows every group member to possibly adopt newly developed methods.

In summary the proposed spiral of network learning therefore provides a model that features the three key elements of network learning: 1) an integration of the inter-related concepts of organisational and inter-organisational learning; 2) an overall recurring learning cycle that comprises the four steps 'knowledge absorption', 'knowledge transformation', 'knowledge utilization', and 'adaptation'; and 3) the important role of 'scaling-up' in the network learning process.

The model answers the second research question by capturing how the coffee supply network has been able to begin adaptation to climate-related risk. The model clarifies how the interaction of multiple agents at different tiers help the millions of globally-dispersed raw material suppliers (farmers) adapt to climate change. The proposed spiral of network learning illustrates a four step learning process and the inter-actions between organisational learning, inter-organisational learning and network learning. It can reasonably be concluded that network learning for the investigated case requires the two other learning concepts to make the coffee supply network adaptable to climate change. First, in order to achieve an outcome of the network learning process which is adaptation, organisational learning is required to turn the revised organisational mental models and behaviours as a result of the network learning process into the practical implementation of the developed adaptation measures. As such, organisational learning can be understood as a part of network learning that facilitates the implementation of developed conceptual changes in network processes and structures. The investigation of the coffee supply network also revealed the need for location specific adaptation measures. As identified in the Coffee & Climate project, a toolbox comprising different general adaptation methods was developed that can be used globally by coffee producers who can then selected the appropriate adaptation measures according to their local needs. This concept is similar to the findings by Knight and Pye (2005) who argue that the conceptual changes for structures and interpretations might be similar at the network level, but may vary in detail if applied to the micro-level.

Second, the investigated supply network comprises for profit- (core supply network agents; main divisions and departments of the standards) as well as non-profit organisations (implementers; smaller parts of the standard organisations). According to the definition of inter-organisational learning which aims to derive organisational benefits as a result of the interaction with other organisations, it can be concluded that inter-organisational learning is a part of the network learning process in the coffee supply network. Profit-oriented organisations only collaborate with other agents in projects if they expect a certain benefit for their company. The roaster Tchibo, for example, follows a hundred per cent Arabica sourcing strategy and is therefore involved in inter-organisational learning projects that help to adapt the Arabica producing farms to the impacts of climate change. However, not for profit organisations such as GIZ, focus on the improvement of the livelihood of farmers, independently whether they produce Arabica or Robusta coffee. Their objective is to change current cognitive models, processes and structures and sensitise the network as a whole to the impacts of climate change. Accordingly, a sector wide approach of network learning is needed

whereby benefit is understood as the adaptation of the supply network as a whole. The next section discusses a number of enabling principles and mechanisms required to achieve network learning, with a particular focus on 'pre-competitive' environment.

11.4 Facilitators of network learning

This section relates to the second research objective and answers the third research question (RQ3) about the enabling principles and mechanisms required to facilitate the proposed network learning process. The research identified a series of enabling principles and mechanisms that are helping the coffee supply network to adapt to climate change.

11.4.1 Enabling principles of supply network learning

Empirical research suggests that in this case, the 4 key enabling principles 'commitment', 'awareness', 'communication' and most importantly 'pre-competitive business environment' facilitate supply network learning. Each principle can be described as follows:

Commitment

In the context of this research, commitment addresses the need to view climate change as an important challenge for supply networks and to be eager to adapt to the risk associated thereto. Commitment is required at both the organisational and inter-organisational levels. As climate change is a global problem, the supply network agents face the same problem and should therefore be committed to participate in inter-organisational initiatives to enable network adaptation. It can reasonably be concluded that without organisational commitment towards problem solving of climate change, a company will not allocate manpower, technical equipment, and financial investments to make the organisation adaptable to climate risks. Moreover, commitment also refers to the willingness to collaborate with other organisations, assimilating their ideas and engaging in joined adaptation measures. Such commitment might be expressed in company and sustainability reports such as in the case of Cafédirect, Tchibo, and Rainforest Alliance, for example. All organisations particularly address climate change and present their plans and activities related thereto (e.g. 'The Gold Standard Annual Report' in the case of Cafédirect). The analysis on their organisational learning processes revealed quite advanced capabilities in the 'understanding' and to some extend in the 'adaptation' steps of the learning cycle which can be related to their commitment on mitigation and adaptation efforts concerning climate change.

Awareness

This enabling principle sensitises the SN agents to the problem of climate change and heightens their perception of the projected environmental changes in the future. It also assists the scaling-up process as it makes the different collaborative projects and programmes on adaptation more widely known across the network. Dissemination of information about the benefits of adaptation measures is critical and agents must be receptive to it. The example of the roaster Paulig showed that this organisation was not aware of the Sustainable Coffee Programme and therefore did not consider to take part in the network learning process – even though it is very open minded to collaboration. So far, the company rather focused on mitigation efforts such as to increase energy efficiency, but at the same time admitted that such activities will not contribute to the need for adaptation of the supply network.

Communication

It is important not only to have the right communication channels across the supply network but also to disseminate the information in a comprehensible form. Although organisations in the supply network may have different educational backgrounds and levels of expert knowledge on supply chain risks, precise communication about climate impacts, and adaptation measures is required. Key messages must therefore be communicated in intelligible language to all project partners and to make it public to the entire industry.

Pre-competitive business environment

Most importantly, a pre-competitive environment is required to facilitate the process of network learning. Pre-competitive can be defined as "*pertaining to the time during research and development in which there is collaboration, but no competition*" (Dictionary 2013). The research revealed that different organisations already collaborate in inter-organisational learning projects such as AdapCC, Sangana PPP, and Coffee & Climate. And despite the participation of non-for profit organisations, the for-profit organisations seek for a benefit for their firm when taking part in such collaborations as proposed by the literature. For example, the roaster Tchibo has a strong interest in the adaptation of coffee growing regions for Arabica due to its sourcing strategy. Moreover, the trader Ecom is not very active in inter-organisational projects even though it was part of the Sangana PPP and still participates in the Coffee & Climate project. However, the trader does not really see a benefit for the organisation and rather views it as problematic in collaborating with other traders it competes with. Accordingly, the investigation of the coffee supply network revealed evidence for the argument that inter-organisational learning is learning between organisations within a

network and with the objective to create benefits for the participating companies, respectively. Yet, as the forecasted impacts of climate change on the global coffee business are too big to be dealt with by single organisations or even inter-organisational learning projects, the approach of network learning is required, i.e. to learn as a group. In order to promote this learning concept, the research revealed that a pre-competitive environment is essential to attract organisations to learn as a group. Such a pre-competitive environment needs to create conditions under which multiple partners can work closely together without this affecting their competitive positions. Examples such as Ecom (trader) and Fairtrade (standard organisation) that request clear action rules of network learning (e.g. accessibility of information, communication, and financing, etc…) provide evidence that organisations will be very reluctant to participate in network learning if the setting is not in a pre-competitive environment with clear and impartial knowledge sharing rules. It can therefore be concluded that a pre-competitive environment is essential to enable for-profit organisations to become members of a group that collaboratively learns about a changing environment without seeking for immediate organisational benefits. A pre-competitive environment is therefore identified as most important enabling principle for network learning.

11.4.2 Mechanisms that enable network learning

On the basis of the four key enabling principles, the investigation of the coffee supply network revealed seven mechanisms to be implemented at the organisational and inter-organisational levels. A mechanism translates the enabling principles into management actions by organisations in the supply network. As illustrated in Figure 11-2, the seven mechanisms in the coffee supply network deal with one or more enablers. Some mechanisms such as ‘Senior manager climate change’, and ‘Electronic documentation’ must be implemented at the organisational level, others like ‘Public-private-partnership’, ‘Climate change platform’, and ‘Orchestrating organisation’ apply at the inter-organisational level. ‘Non-scientific language’ and ‘Scientific research’ are mechanisms that relate to both levels. In Figure 11-2 it is shown how each mechanism can help to implement the four enabling principles. Also ‘orchestrating organisation’ is highlighted as the most important mechanism as such an organisation might integrate the functions of the remaining mechanisms into a single role as explained in the following discussion.

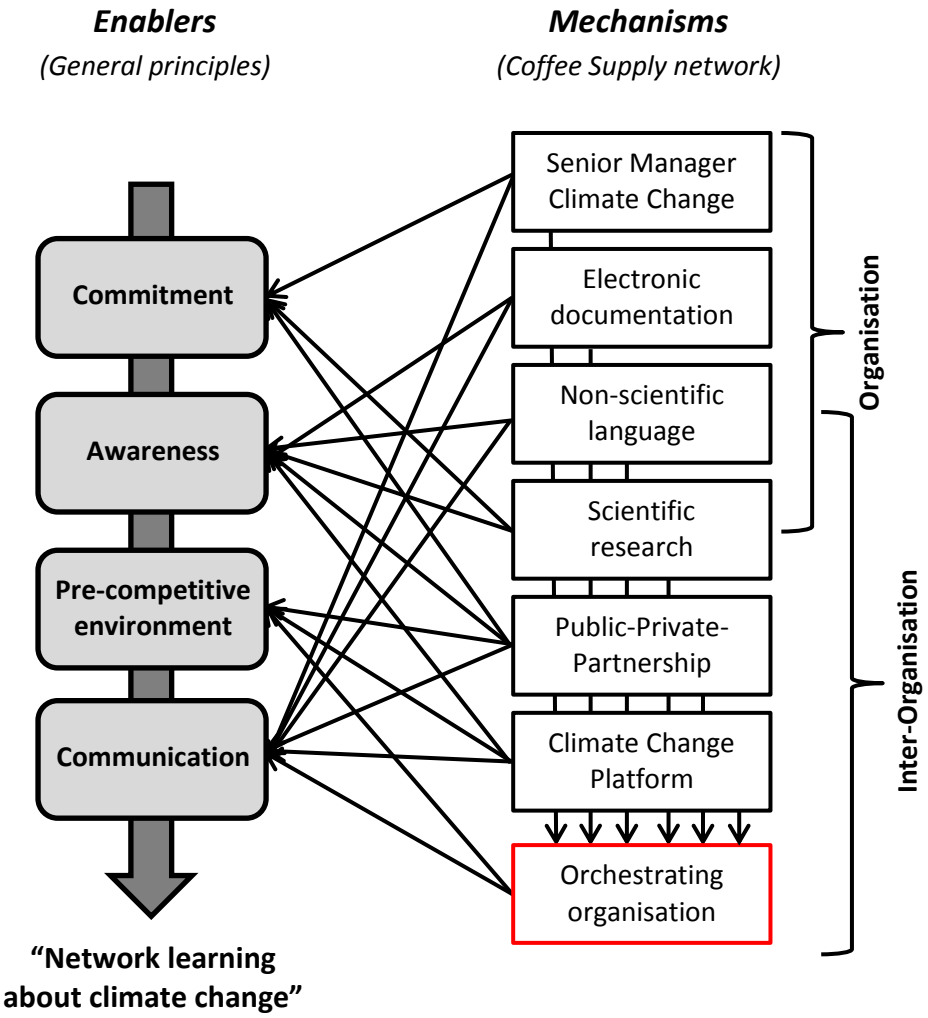


Figure 11-2: Relationships between enabling principles and mechanisms in the coffee supply network

Creation of Senior Management post dealing with Climate Change

Climate-related activities are often placed under the heading of corporate social responsibility (CSR). As part of CSR many organisations have a sustainability agenda comprising not only environmental, but also social activities that particularly address the farmer community (according to UTZ). Therefore, climate change is only one topic amongst others such as child labour, living conditions, education and fair pricing. For this reason CIAT argues the need for a senior manager dedicated to climate change because the CSR management team "*does not even know about all this climate stuff"* (according to Laederach/CIAT). The establishment of a senior manager role dedicated to climate change represents an organisational commitment to deal with this particular problem more intensively *(enabler commitment).* A 'climate change manager' can consolidate and co-ordinate all internal activities related to adaptation and

interact with other external managers throughout the network with similar competences and expertise *(enabler communication).*

Electronic documentation

The field research revealed the need for a good system of electronic document exchange in the coffee supply network particularly due to its fragmented structure. By storing documents in digital form organisational knowledge can be preserved as staff come and go, and can be made accessible to employees in different countries (according to Cafédirect). Electronically documented knowledge created at the organisational level can be more easily shared between organisations and is an essential mechanism of inter-organisational learning provided there is a commitment to share knowledge in the first place. The interview with Nestlé clarified that proper documentation enables an organisation to process information bottom-up from the farm level to senior management and vice versa. Accordingly, electronic documentation ensures quick and effective communication to facilitate the process of network learning *(enabler communication).* In the case of Rainforest Alliance, electronically stored information is also used to create a web-based training platform that includes uploaded training material used to inform farmers and other stakeholders about climate change, the certification schemes and good agricultural practice *(enabler awareness).*

Non-scientific language

As many different organisations are involved in the network learning process, an easy to understand language is required. Researchers from CIAT and NRI, and field agents from SMS and Tchibo explained that climate change is a complex topic to understand and must be presented to farmers and the employees of traders and roasters in simple terms *(enabler communication).* Generally, any scientific terminology should be avoided. For example, presentations and reports should rather speak of 'improvements in agricultural practices' instead of 'increasing the resilience of the raw material supply' *(enabler awareness).*

Scientific research

As argued by Rainforest Alliance, not only operational improvements in good agricultural practices make a supply network more resilient to climate change, so too do scientific advances in, for example, the development of new varieties of coffee. The results of this scientific research must subsequently be communicated through the supply network. This long term strategy requires strong financial commitment to test new plantlets and research for more disease resistant varieties. In the case of the Kenyan coffee growing regions, a

collaborative project between SMS and the local 'Coffee Research Foundation' (CRF) resulted in the development of a new coffee variety named 'Batian'. This new species is more resistant to coffee berry disease and coffee leaf rust which have been strongly increased as a result of climate change *(enabler commitment).* Scientists specialising in tropical agriculture have detailed knowledge and carry out localised analyses of the likely future climate conditions in each coffee production region. It can reasonably be argued that their expertise will increase the awareness of the problem of climate change amongst the farmers, but also amongst the other core and supporting organisations in the coffee business *(enabler awareness).*

Public-private-partnership

In order to ensure a pre-competitive environment, all companies interviewed stated that there is a need for a neutral leader capable of coordinating the interests of different agents. All identified inter-organisational projects and programmes were set up as public-private-partnerships (PPP) with a public organisation taking the role as lead coordinator. Organisations such as GIZ have considerable experience in orchestrating multiple project partners and have not used project outcomes to exploit their own market positions (according to Cafédirect, Tchibo). A PPP can also ensure clear action rules. These rules mainly address the publication of project findings and financial investments. Governmental regulations provide the legal basis for PPP initiatives and prohibit discrimination against single organisations. These regulations ensure that the outcome of the projects are made public and also that all participants keep within anti-trust laws and national regulations for collaboration. Furthermore, PPP initiatives have also meet financial investment rules (*enablers pre-competitive environment and communication)*. A PPP acts as a catalyst for collaborative projects (*enabler commitment*) and raises awareness of climate-related activities. Due to its openly-communicated action and partnering small holders, more SN agents are made aware of the latest approaches to understand and adapt to climate change. As a measure of the importance of PPPs, every interviewee consulted knew about the investigated projects (AdapCC, Sangana, Coffee & Climate) and they pointed out their interest in the project outcomes that may influence their future climate-related activities. Moreover, the PPP structure can enable easier access to the banking sector (according to Ecom, Tchibo, Nestlé, and Julio Alfaro) *(enabler awareness).*

Climate Change Platform

To facilitate network learning, a platform concept under which all climate-related activities in the coffee supply network must be implemented. In the context of this research, platform might be defined *as place that provides organisational capabilities and technical equipment to moderate SN*

agents, and store and disseminate data, information, and knowledge. According to 4C, acceptance of such a platform is increasing and offers the opportunity for network learning by bringing together agents from different tiers with different functions. A platform can therefore give climate change a dedicated forum for discussions. Many interviewees (e.g. Tchibo, Nestlé, HRS Neumann, etc…) view the platform attached to the 4C organisation in the future. Empirical research suggests that the membership principle of 4C is likely to result in a widespread acceptance. As organisations with different market power have become members of 4C, the platform can also channel top down leadership from large roasters and traders, and bottom-up processing of local knowledge from the farmer communities. Supporting this approach, Tchibo argued that *"the big ones should say that we have gathered our experience, but now we need to establish a toolbox that we push through. There should be one direction now, and then [farmers] can choose locally from this toolbox what is appropriate to their situation"* (interviewee J). Furthermore, a specific forum for discussing climate-related activities should also lead to greater priority being given to adaptation over mitigation as this trade-off is currently strongly discussed within the coffee business. With reference to Lee's (2004) triple A-SC concept, alignment of varying strategies is a key principle to facilitate risk mitigation in a supply network. Therefore, it can reasonably be concluded that unaligned strategies on climate change mitigation and adaptation hinder the coffee supply network from becoming resilient to climate change *(enabler commitment).* As a consequence, a moderating organisation such as 4C should operate a platform and host all sector wide knowledge and adaptation measures to climate change for the purpose of alignment. Its neutral position ensures all member organisations have equal opportunities for participation in the network learning process and ensures general access to all created knowledge and adaptation measures *(enabler pre-competitive environment).* Moreover, the platform also helps to raise levels of communication and awareness by absorbing knowledge from experts; transforming it into a simplified language; designing a range of adaptation measures; and supervising the adaptation progress of the small holder farmers in the coffee growing countries (*enablers awareness and communication*).

<u>Orchestrating organisation</u>

A very important mechanism is the 'orchestrating organisation' as this role was requested by nearly every investigated supply network agent (e.g. Nestlé, Tchibo, Ecom, etc…). The interviewees understand orchestrator as a management function that organises all relevant processes of network learning to achieve the outcome of a sector-wide adaptation strategy to climate change and its implementation. An orchestrator may take a 'meta-role' and can manage the supply network by ingesting the six different roles as presented by Knight and

Harland (2005). In order to take the different roles, the orchestrating organisation in the coffee supply network should preferably integrate the remaining identified mechanisms as summarised in Table 11-3.

Mechanisms (coffee supply network) to be integrated in the function of an orchestrator	**Network management roles according to Knight and Harland (2005)**
Senior Manager Climate Change	Co-ordinator, Supply policy maker and implementer
Electronic documentation	Information broker
Non-scientific language	Information broker
Scientific research	Innovation facilitator
Public-Private-Partnership	Co-ordinator, Supply policy maker and implementer, advisor, network structuring agent
Climate change platform	Information broker, Co-ordinator, network structuring agent

Table 11-3: Mechanisms and roles of network management in the coffee supply network

Each integrated mechanism and role can be described as follows:

- Senior Manager Climate Change - The orchestrating organisation needs to appoint a senior manager that has control about sufficient financial and human resources to co-ordinate the network learning process. Moreover, the lead manager is responsible to set priorities and develop policies for communication, knowledge sharing, and financing as part of the network learning process. Finally, such a position can also take a role as conflict manager between the different interests of the agents in the coffee supply network. The latter issue particularly addresses the spending of money in the context of climate change. Whereas some organisations (e.g. standards, etc…) would like to see the money spent on carbon related projects, other agents (e.g. roasters, etc…) focus on adaptation activities.
- Electronic documentation and non-scientific language - These two mechanisms mainly refer to the role of information broker. An orchestrating organisation needs to have strong IT capabilities and must create an electronic information pool that is frequently updated. The electronic data pool is highly important as it facilitates transparency in the global coffee supply network and allows every network agent to quickly access the latest knowledge and reports. An orchestrator should also ensure that the coffee

supply network uses uniformly agreed specific terminology and avoids scientific language.

- Scientific research - Even though the orchestrator is unlikely to conduct own research, it can take the role of innovation facilitator. Both interviewed scientists clarified that they will only contribute their research findings to the coffee supply network if they are subcontracted. The current procedures in the coffee supply network revealed that researchers carried out similar activities for different projects, i.e. double work, and were only subcontracted for part-analysis, lacking a complete presentation of the latest research available. For that reason, the orchestrator's role is to co-ordinate the research activities and initiative new research by contracting scientists in a co-ordinated manner to avoid doubling of research activities. This process also means to align different interests of researchers to generate a detailed understanding of the forecasted climate change, but also of the localised impacts of climate change risk.
- Public-Private-Partnership - The orchestrator might preferably be an organisation from the public sector. The research revealed that an organisation such as GIZ has a strong track record in chairing learning and is highly accepted by the other agents within the coffee supply network. As such, the orchestrator can easily establish a public-private partnership programme for network learning that structures all activities. The 'public' component ensures to meet strict policies concerning publishing, communication, and financing.
- Climate change platform - Preferably the orchestrating organisation should also be the holder of the climate change platform in order to avoid conflicts in leadership and competences. The current situation in the coffee supply network is that GIZ and IDH are the orchestrating entities that co-ordinate network learning and 4C being in the transformation phase towards a climate change platform. This leads to some confusion amongst the network members as they preferably see both mechanisms in the same hands. For that reason, the future plan is that 4C may also takes the orchestrating function as it currently lacks capabilities to fulfil the remaining roles as discussed.

In summary, an orchestrating organisation is the most important mechanism as it can create a pre-competitive environment to enable network learning throughout the coffee supply network. To best fulfil its role to manage the network learning process, the orchestrator should have capabilities in all six areas presented by Knight and Harland (2005) in order to create a pre-competitive environment for network learning. Yet, the displayed roles might also

be fulfilled by other members of the supply network at the same time. Despite the fact that an orchestrator is strongly linked to the mechanisms 'public-private-partnership' and 'climate change platform' this 'orchestrating organisation' mechanism is presented separately as its function also may be taken by different agents. In smaller scale inter-organisational learning projects, GIZ assumed the role of project orchestrator. At a sector wide scale as part of network learning however, possible organisations to host such an integrated function might be the 'IDH programme', the 'International Coffee Organization' (ICO) or the membership organisation 4C Association.

11.5 Summary

The analysis of the coffee supply network provided answers to all three research questions. Initially, the investigation revealed that organisational as well as inter-organisational learning takes place in the coffee business, but that a supply network learning process is required to adapt the coffee business as a whole to climate risk. To model the network learning process, a spiral concept was adopted from the knowledge management literature and used to design a framework that illustrates a) the four steps of learning (knowledge absorption, transformation, utilization, and adaptation); b) the integration of organisational and inter-organisational learning; and c) the scaling-up process from pilot projects to the network as a whole. In order to operationalize the proposed network learning framework, a number of enabling principles and mechanisms were identified. The case study results have been used to examine the relationship between four key enablers and seven mechanisms that lie at the heart of the supply network learning process for climate change adaptation. In particular, the research revealed that a 'pre-competitive' environment is central to facilitate network learning as otherwise organisations might not be attracted to learn as a group. More specifically to the coffee supply network, the 'orchestrating organisation' was found to be the most important mechanism to implement the enabling principles and to facilitate network learning. It can be concluded that an orchestrator might integrate the different roles from other mechanisms to manage network learning in a co-ordinated approach. Such an organisation is preferably a supporting and not a core network agent and has experiences in moderating different interest and learning capabilities.

Chapter 12: Conclusion

12.1 Introduction

Supply networks are highly complex, and will need sophisticated mechanisms that ensure effective adaptation to climate-related risk. Climate change is identified as a major external risk factor to supply networks. As such networks require a structured supply chain risk management approach to ensure network resilience to a changing PESTEL environment.

Agility, alignment, and adaptation are identified in the SCRM literature as a means of reducing supply chain risk; it is argued in this work that adaptation in particular is an appropriate risk mitigation measure within the context of climate change. The literature in SCRM, however, offers few insights into the mechanisms and processes of adaptation. A better understanding of the mechanisms for adaptation required a review of the literature in knowledge management and organisational learning.

The literature shows that learning passes through a two phase process of 'understanding' and 'adaptation' and can be designed as a recurring cycle comprising four steps 'knowledge absorption'; 'knowledge transformation'; 'knowledge utilization' (phase of understanding); and 'adaptation' (phase of adaptation). By integrating the findings from the literature, it was possible to devise two *a priori* models of organisational and inter-organisational learning in the context of climate change. These were designed to frame the subsequent investigation into the learning processes of a global supply network highly exposed to climate change – namely the coffee production and distribution network.

To structure the field research, three research questions were developed which address 1) the type of learning required for adaptation; 2) the process of network learning; and 3) the enabling principles and mechanisms that facilitate network learning.

The case study methodology was chosen as an appropriate research approach for the thesis. As the research is of an exploratory nature aiming to reveal how supply networks can adapt to climate change, an in-depth analysis of a single supply network was carried out to try to understand the learning processes and underlying mechanisms. The coffee supply network was identified as a suitable case for the field research as it encompasses a complex multi-tier structure of organisations, is highly dispersed geographically and, significantly, it is already sensitive to and is taking action in response to the impacts of climate change. The global coffee farming community is highly exposed to extreme weather and rising temperatures.

A total of 17 core and supporting agents in the coffee supply network were interviewed to collect qualitative data about how they learn about and adapt to climate change. The *a priori* models developed in this thesis were used to structure the interpretation of this empirical data providing evidence of both organisational as well as inter-organisational learning.

The following sections present the key findings of this research, summarise the thesis' academic contribution to theory and managerial implications, and also discusses the generalizability and limitations of this research and possible directions for future research.

12.2 Key findings

The overall research aim of the thesis was to determine how supply networks can adapt to climate change and its related risk factors. This research proposes network learning as a key element in this adaptation process. Only a collaborative learning approach between and by network agents enables the network to complete the four step learning cycle. By combining different learning strengths, the network as a group can overcome potential weaknesses in the learning cycles of individual organisations and hence as a whole can understand the impacts of climate change, develop appropriate adaptation measures and eventually implement them. At the outset three research questions were posed. In the light of the analysis of primary and secondary data, they can now be answered:

RQ1*: What type of learning enables companies and networks to adapt to climate change risk?*

Learning encompasses understanding and adaptation, and passes through a four step cycle that can be deployed at the organisational and network levels. The research found evidence that individual agents do not learn or only partially learn which constrains their adaptive capability. Two propositions were tested:

P1*: Individual organisations in a supply network <u>do not</u> learn about climate change, i.e. they do not understand and adapt to climate risk.*

The research found that none of the agents is able to very strongly pass through all four steps of the proposed learning cycle. Rather, core and supporting supply network agents follow certain steps, but not enough to understand climate change impacts, develop adaptation measures and implement them independently from each other. This weakness would be marginal if the farmers were strong in organisational learning as they are the most exposed agents in the coffee network. It is reasonable to conclude that if farmers could independently adapt their plantations to the direct impacts of climate change, the entire network would be much more resilient to changing environmental conditions. The investigation clearly showed

that farmers are very strong in 'knowledge absorption' and in the implementation of 'adaptation' measures, but weak in the other steps. They have already observed and suffered from the impacts of climate change, but the fragmented smallholder structure and the relatively low level of education prevent them from transforming their experiences into adaptation strategies. For that reason, the raw material suppliers cannot adapt their businesses to climate change independently and consequently leave vital parts of the entire supply network exposed to climate risks. Proposition 1 is therefore verified.

The analysis of the agents further downstream in the supply network revealed stronger competencies in knowledge transformation and utilization and hence the capability to develop possible adaptation measures. All supply network agents tended to follow all steps in the organisational learning cycle, but they varied in the strength with which they executed each of the four steps. Across the four collaborative projects and programmes investigated it was found that as a result of inter-organisational learning, organisational learning strengths were combined in a way that promoted adaptation. These findings support the second proposition:

***P2**: Networks do learn and adapt to climate change.*

The three projects (AdapCC; Sangana; Coffee & Climate) on inter-organisational learning clearly showed that the interaction between the project partners enabled 1) the creation of a mutual knowledge base about the impacts of climate change; 2) the translation of this knowledge into adaptation measures; and 3) the implementation of these measures at the farm level. The farmers benefitted from the other agents' capabilities and resources in the knowledge transformation and utilization steps whereas the organisations outside the farm level profited from the commitment of the smallholders to implement the adaptation measures. These findings support the theory that inter-organisational learning takes place if organisations collaborate with the objective to primarily obtain strong benefits for the own company. This argument is underpinned by the fact that organisations only participated in projects that were related to their own business. For example, Cafédirect collaborated only in a project which aimed to improve the livelihood and adaptation capabilities of farmers who are part of the 'Cafédirect Producer Foundation' from which only this roaster procures. However, the investigation also revealed that the three inter-organisational projects are limited in time and scale and only result in the adaptation of a tiny part of the coffee supply network, e.g. the relatively small farmer community being part of the 'Cafédirect Producer Foundation'. For that reason, for-profit as well as not-for-profit organisations expressed their requirement for a centred-supply network approach in learning. As a result, the roasters initiated the Sustainable Coffee Programme (SCP/IDH programme) to facilitate learning as a

group of organisations that are part of the coffee business; referred to in the literature as 'network learning' (Knight and Pye 2004; 2005).

In summary, the field research revealed that the coffee supply network will not become adaptive as a result of organisational learning as particularly the farmers are unable to develop appropriate adaptation measures. Even though inter-organisational projects with selected supply network agents achieved some level of local adaptation within the participating farmer community, these projects do not reach out to the supply network as a whole and are hence insufficient for supply network adaptation. To achieve network adaptation to climate change risk the global and complex coffee supply network requires the concept of network learning, i.e. the process of learning as a group. Network members recognise the need for a collaborative learning approach in a transparent and pre-competitive manner and hence established the 'Sustainable Coffee Programme' to attract as many organisations as possible with the objective to learn as a group about the impacts of climate change for the benefit of the supply network as a whole.

***RQ2**: What is the network learning process?*

Based on the empirical findings from the investigated coffee supply network and recognising that learning needs adaptation to actually achieve a change in existing processes and structures, the following definition of network learning is proposed:

> *"Network learning is an integrated and co-ordinated process of knowledge absorption, transformation and utilisation by network agents as a group which enables the network as a whole to adapt to a changing environment"*

Network learning in the coffee supply network can therefore be described as a co-ordinated and collaborative process which enables the creation of a large knowledge base about the location-specific impacts of climate change and the development of a globally applicable toolbox of adaptation measures to choose from according to the specific needs.

To conceptualize the network learning process, a model framework was developed on the basis of the observations in the coffee supply network as illustrated in chapter 11. This adopts a spiral design element originally developed in the knowledge creation model of Nonaka (2004), but uses it in network learning. The spiral design reflects the interactions between the three key elements of the network learning process: *1) the four step recurring learning cycle;*

2) the integration of organisational and inter-organisational learning activities; 3) and the scaling up process; each summarised as follows:

1) The four learning steps occur at different positions in the spiral. Knowledge absorption refers to the experience, observation, and information collection of a changing environment and is strongly linked to the concept of organisational knowledge creations as introduced by Nonaka (2004). Adaptation as outcome of the network learning process can take two forms: first, it can mean conceptual changes in the processes and structures of the supply network to facilitate adaptation of the exposed supply network agents. Second, physical adaptation includes the actual implementation of adaptation measures (e.g. changes in irrigation, mulching, planting of new more robust species, etc…) by the small-holder farmers. Both, knowledge absorption and adaptation rather happen at the organisational level as the supply network agents are the entities that need to implement the learning outcomes. In turn, knowledge transformation and utilization rather happen at the inter-organisational level. The former step aims to create a mutual knowledge base about the future climate and its impacts on the coffee business whereas the latter step refers to the collaborative development of adaptation concepts for network processes and structures, as well as for practical adaptation measures to be implemented at farm level.
2) This interaction between organisational and inter-organisational activities is integrated into the concept of network learning. It can be argued that network learning is influenced and supported by organisational as well as inter-organisational learning. The research clearly revealed the need for network learning, i.e. the collaborative learning of all network members as a group for a mutual benefit. However, it also clarified that the complex and global structure of the coffee supply network requires strong organisational learning capabilities as well as inter-organisational learning projects. It is reasonable to conclude that the outcomes of pilot projects (e.g. AdapCC, Sangana PPP, etc…) with limitations in time, geographical area, and resources, serve as basis for network learning. The finding from the IDH coffee programme (established for network learning) that it took almost a year to align the members' different interests before actually starting the network learning process underpins the argument that a learning outcome such as the toolbox developed by the 'Coffee & Climate' project, would have either been impossible or taken far too long in network learning. Organisational and inter-organisational activities can therefore be understood as integral and supporting parts of the network learning process in the

coffee business. Moreover, the underlying dynamics of a complex adaptive supply network stress that learning is not linear, but that the outcome of network learning in the form of adaptation impacts the network structures and leads to co-evolution with the environment. Co-evolution therefore refers to changes in the structures and dynamics of the supply network and the network learning process as a result of adaptation to a changing environment caused by climate change.

3) Considering the previously mentioned difficulties in network learning, a scaling-up process is recommended. It can be argued that in order to make the coffee supply network as a whole adaptable to climate change, initially pilot projects in the form of inter-organisational learning projects are required. The participating organisations, particularly the for-profit ones, have a strong interest in adapting those parts of the supply network that are relevant to them, e.g. to adapt farmers they source from. However, the nature of such smaller projects does not suit the need for adaptation of the supply network as a whole. The outcomes of the inter-organisational learning projects should therefore be transferred to the network learning level that may happen in the form of international programmes, such as established by IDH, for example. At this stage, the group can learn as a whole about the impacts and develop solutions that benefit every member of the supply network, provided there is a pre-competitive environment. Such a condition would then attract more and more organisations within the network to join the group as a learner and reach out more organisations to implement the developed adaptation concepts.

In summary, the chosen model design illustrates the three distinct features of the proposed network learning process. Firstly, the modelled process integrates the four learning steps (knowledge absorption, knowledge transformation, knowledge utilization, adaptation) which occur at different positions in the spiral. Secondly, the spiral design illustrates the integration of organisational and inter-organisational activities. And thirdly, the framework model indicates that the network learning process passes through different stages in moving towards the adaptation of the supply network as a whole. The aggregating process integrates more and more organisations, knowledge, and adaptation abilities from smaller trial projects to broader supply network initiatives. This scaling-up process as part of network learning was revealed to be beneficial as it allows bigger programmes to build on previous findings and to remain manageable even if hundreds of organisations participate in a collaborative initiative. The proposed network learning model fits with the coffee supply network and maybe with other

agricultural supply networks that have a similar structure of the supply base. The generalizability of the model is discussed later in this chapter.

***RQ3**: What are the enabling principles and mechanisms that facilitate the network learning process?*

The final research question addresses the underlying enabling principles and mechanisms that facilitate the proposed network learning process. Enablers are defined as overall principles which facilitate network learning in supply networks. A mechanism translates the enabling principles into management actions by organisations in the supply network. Accordingly, mechanisms practically implement the theoretical enablers, and are specific to every supply network. Four general enabling principles were concluded and seven mechanisms in the coffee supply network were identified. As shown, every mechanism (*Senior Manager Climate Change, Electronic documentation, Non-scientific language, Scientific research, Public-Private-Partnership, Climate Change Platform, Orchestrating organisation*) facilitates one or more of the four enablers: *commitment*, *awareness*, *pre-competitive environment*, and *communication* as discussed in detail in chapter 11.

The research revealed that the most important enabling principle for network learning is 'pre-competitive environment' and that in the case of the coffee supply network the mechanism 'orchestrating organisation' is critical to implement the network learning process. It can be concluded that network learning, i.e. learning as a group, requires a pre-competitive environment, particularly if for-profit organisations that normally compete with each other plan to collaborate in learning. The example of the trading organisation Ecom showed that it was very reluctant to join the learning network group as it did not want its business to be affected by working together with its biggest rival 'The Neumann Group'. Only by distinguishing between competitive and pre-competitive activities and by clarifying the rules for network learning in advance, market rivals can be attracted to participate in network learning with the objective of a sector-wide benefit rather than a direct organisational benefit. A similar example of rivalry that may hinder network learning was found in the market of standard organisations. Standard organisation (e.g. Fairtrade, Rainforest, UTZ, etc…) see the opportunity to differentiate from competitors by developing a climate adaptation component that can be added to their certification schemes and that is likely to increase the sales of their seals and certificates. Accordingly, each standard organisation has been conducting some independent research and only by establishing pre-competitive conditions did they agree to become members of the 4C Association and are now generally willing to collaboratively learn

as a group in the defined areas. Finally, the orchestrating mechanism in the coffee supply network is revealed as a critical success factor in network learning. As roasters and traders have relatively equal powers in the coffee supply network, an orchestrating organisation that is not directly involved in the processing of coffee and that is accepted by all core and supporting agents is required to co-ordinate network learning. The research revealed that such a function, even in smaller inter-organisational projects, proved to lead to successful learning outcomes. The orchestrator can fulfil different management roles to advise, co-ordinate, inform, integrate, and lead the other participants in the inter-organisational as well as network learning process. It can therefore be concluded that without such an orchestrating role, such as that taken by GIZ or IDH in the coffee supply network, organisations from different tiers, with different functions and with similar powers would be unable to learn as a group and would be constrained to smaller inter-organisational projects for their own benefits. That however would not result in the adaptation of the complex coffee supply network with its highly dispersed small holder supply base.

12.3 Academic Contribution

This research contributes to the emerging field of research on the adaptation of logistics and supply chain management in three ways: theory, methodology, and empirical data.

Contribution to theory

Climate change poses an important external risk to supply networks. In this study, the term supply chain climate risk (SCCR) has been developed to describe this risk and is defined as follows:

> *"Supply chain climate risk (SCCR) is the probability and direct and indirect consequences to the supply chain emanating from changes in the political, economic, social, technological, environmental and legislative environment caused by climate change"*

The SCRM literature suggests that concepts such as agility, alignment and adaptation (Lee 2004) are necessary for risk mitigation, with most literature focused strongly on the design of agile supply chains. Agility is useful to cope with short term disruptions and disturbances, but an agile supply chain is not necessarily able to adjust to the long term effects of climate change. Climate change requires a change in network level processes and structures in response to current and projected impacts. Therefore, adaptation has an important role to play in the mitigation of climate risk. It is also linked strongly to Christopher and Holweg's (2010) argument that there is a need for 'structural flexibility' in supply networks in response

to worldwide mega trends impacting businesses in an era of turbulence. As climate change is such a mega-trend, structural flexibility should bring adaptation into supply networks. Accordingly, this research contributes to SCRM literature by proposing and illustrating 'adaptation' as a way of mitigating climate related risk.

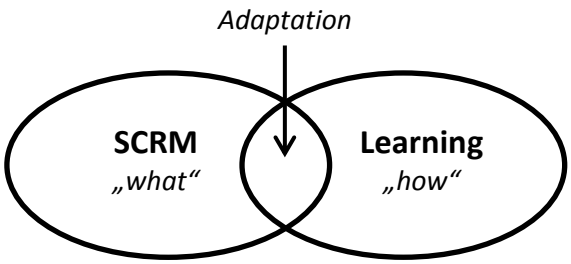


Figure 12-1: The research gap

As illustrated in Figure 12-1 the SCRM literature only suggests 'what' needs to be done to make a supply network resilient to climate change. It does not explain 'how' adaptation might be achieved. In an effort to address this 'how' question, this study has looked into the literature in knowledge management and particularly learning to see what processes supply networks are likely to follow to adapt to climate change. This research goes some way to bridging the gap that currently exists between the SCRM and learning literatures, by proposing a network learning process that incorporates adaptation. On the basis of the literature review and fieldwork, a spiral model of network learning has been devised to illustrate the process of network learning in this context. The research reveals four general principles that enable network learning with 'pre-competitive environment' being the most important. To practically implement the enabling principles, seven mechanisms that are specific to the coffee supply network have further been identified; the mechanism 'orchestrating organisation' is identified as critical in the organisation of network learning in the complex and global coffee supply network.

Methodological contribution

This research used a single case study methodology to investigate the complex coffee supply network comprising numerous organisations spanning the globe. The approach proved to be very successful in collecting empirical data from many different positions within the investigated case to conclude on an overall process of network learning. The following lessons have been learned about the practicalities of doing this type of case study research:

- An in-depth analysis of a global supply network is very time-consuming. Not only a single organisation must be committed to contribute empirical data, but a number of

different agents must be willing to take part in interviews and provide an insight into their business. It took a lot of time to contact companies and advertise the research. Even though the coffee sector is relatively open to innovative research, strong efforts were needed to attract organisations to participate in the research. Therefore, a certain number of organisations should be agreed to take part in the investigation prior to setting up a single case study methodology.

- The in-depth investigation of a single supply network is also difficult due to its global scope and limited access to all SN agents. In the case of the coffee supply network, organisations work in all continents and particularly the farmers were difficult to approach. The practicability of a single case study research is therefore always be limited by the accessibility to the globally dispersed SN agents.
- Finally, an *a priori* framework should be developed to structure the empirical data collection process and the analysis of the received information. As participants from different organisations are likely to have varying educational backgrounds, positions, and experiences, the *a priori* structure helps to focus on the research theme in different interview situations.

Empirical insights

In total, 17 semi-structured interviews were conducted with organisations within a single large supply network concerning their intra- and inter-organisational learning capabilities about climate change. The richness of the collected primary data from a diverse set of interviews (e.g. farmers, traders, roasters, scientists, etc…) enabled the researcher to get a deep insight into the investigated case and to explore the inter-relationships in network learning.

12.4 Recommendations to management

Based on the empirical data collected from the coffee supply network, the thesis outlines a series of practical management initiatives that would assist the process of network learning about climate change adaptation:

- Managers from all different kinds of organisations initially need to understand the coffee supply network as a complex adaptive system which contains dynamic structures and processes that consistently change and co-evolve with the environment. According to the nature of such complex adaptive supply networks, a single organisation and manager cannot oversee the network as a whole including its global and dynamic processes and in the context of climate change its projected impacts for the coffee business. Executives should therefore recognise that their organisation is likely to have weaknesses in the learning cycle and that efforts by a

single company or even a smaller group of organisations will not be enough to increase the resilience of the coffee supply network to climate change.

- At both, the organisational as well as inter-organisational level, managers must implement the proposed mechanisms to facilitate network learning. Whereas the organisational mechanisms can relatively easily be implemented, mechanisms such as 'climate change platform' and 'orchestrator' are much more difficult to agree on. It is recommended that a supply network that follows the proposed network learning process selects an organisation that orchestrates and hosts the climate change platform at the same time and is preferably a non-privately organised and non-core agent in the supply network. Further requirements are experiences in programme co-ordination and leadership qualities that balance the different powers and interests in the supply network.
- As a pre-competitive environment is found to be essential for network learning, managers at the organisational level need to determine which parts of the business they perceive as pre-competitive and which as competitive. This distinction must be made prior to joining the network learning group. The orchestrator at the network level, such as the IDH programme, for example, must align the different organisational perceptions towards pre-competitiveness and create a commonly accepted learning environment for the group as a whole. This process also includes the explicit formulation and clarification of the objective and outcome of the network learning process.
- Considering the complexity of the investigated supply network that is particularly caused by the fragmented supplier structure and non-uniform global impacts of climate change, it is recommended not to initiate network learning prior to creating a reasonable knowledge base and determining a certain scope of the learning process and outcome. Decision makers must accept that beside the learning process as a group at the network level, inter-organisational projects at smaller scale and with a limited number of supply network agents can be carried out. Considering the dynamics of the supply network, pilot projects are more flexible and may better address changes in the environment and internal network structures without necessarily being initiated by the network learning group. Preferably, the learning outcomes from these inter-organisational learning projects then feed the network learning process.

12.5 Generalizability of the findings

Although the empirical research was confined to the coffee supply chain and the network learning model based on this sector, the proposed model may fit similar supply networks and some elements may be generalizable. Depending on the type of network and climate risk exposure, the following can be concluded:

Agricultural supply networks with a similar supply base

The developed network learning model may be generalizable to other supply networks within the agricultural sector that have a similar dispersed small holder supply base. For example, supply networks (e.g. tea, banana, etc…) that source products grown in the tropics and sub-tropics (in equatorial regions worldwide). These supply networks have a similar exposure to climate risks and face the same difficulties to reach out to farmers with adaptation measures. The thesis findings should therefore be of interest to businesses of different size and at different points in such supply networks. Each organisation, independent of size, market power or capabilities, is part of the interdependency between agents in a supply network and should participate in the network learning process. Moreover, the continuum of exposure to climate change is comprehensive and location specific which should encourage managers to quickly learn about their exposure to supply chain climate risk. To help decision managers learn, the revealed mechanisms from this research can equally be applied to other supply networks in tropical agriculture.

Agricultural networks with a different supply base

Other agricultural supply networks, such as in cotton and soya, are also likely be exposed to climate related risk, but may vary in their degree of exposure and the structure of their supply base. Whereas coffee and tea are highly sensitive to climate change, crops such as cotton and soya are more robust and require less specific environmental conditions (e.g. temperature and rain seasonality, etc…). However, extreme weather can significantly harm these crops, and adaptation activities such as the use of fertilizers might also reduce productivity. Yet the supplier base is much more condensed according to Rainforest Alliance and CIAT, which makes it easier to reach out to farmers and collectively develop adaptation measures to improve existing agricultural practices. As such the developed network learning process could also be applied to this type of supply network even though the speed of learning may vary and the mechanisms might be differently designed. A condensed supply base might require fewer pilot projects at the inter-organisational level with a limited number of organisations involved; the network members would be brought together much quicker to learn as a group. The seven mechanisms might be applied as well, but vary in their significance to enable network learning.

For example, *non-scientific language* is less important as cotton farmers are usually well-educated and the function of a *climate change platform* is less relevant as the problem of climate change is already discussed in the different cotton associations (e.g. Cotton Australia).

Non-agricultural supply networks

The developed network learning process might not be generalizable to supply networks without an agricultural supply base. First, other industries might not be directly affected by climate change and are projected to suffer only little from future direct impacts or from indirect impacts via changes in the PESTEL environment. The automotive industry, for example, might suffer from increased complexity in logistics operations due to a rising number of disruptions and the supply base might become more exposed to climate change. Proposed solutions might consider moving production to a much safer geographical region and change procurement processes from global to local sourcing, for example, which in the agricultural business is not possible. Accordingly, learning efforts with the objective to adapt the automotive supply network have not been identified as they are currently not evident. Second, the structure of the investigated supply network might be different from other networks which are dominated by OEMs or a very small number of powerful agents. Accordingly, such networks do not need to create a pre-competitive environment and the orchestrating function as well as the other roles are normally taken by the leading network member. For that reason, the learning process at the network level that is influenced by organisational and inter-organisational activities is likely to be different from the one developed from empirical evidence in the coffee supply network. However, as this research is exploratory in nature, the outcomes might also be considered by industries that are currently not highly exposed to climate risk, but that are likely to become vulnerable in the near future. The presented network learning process might then help such supply networks and act as a reference to quicker and more efficiently adapt to the impacts of climate change.

12.6 Limitations of the research

The research has several limitations:

1. The adoption of the case study methodology limits the generalizability of the results. With more time and greater resources it would be possible to extend the field work across broader cross-section of supply networks and sectors to compare the challenges likely to be posed by climate change adaptation and the ways in which organisations are currently dealing with them. Preliminary field work revealed,

however, in many sectors companies are showing very little interest in the possible impact of climate change on their supply chains. As McKinnon (2013, p. 24) has observed, *"the prevailing view of many logistics managers is that climate change is just another risk factor to build into their business continuity and resilience models. Allowance is already made for bad weather in the management of supply chains and all that may be required is a bit more contingency planning to accommodate extreme weather conditions".* Managers holding these views will be difficult to involve in supply chain adaptation research at this stage.

2. The chosen philosophical stance of this thesis accepts the subjectivity in the interviewees' answers as the data collected is predominantly of a qualitative nature. Despite the fact that data was triangulated whenever possible, full verification of the interviewees' positions remained difficult. Therefore, the research conclusions are not based on quantitative and more objective data, but are possibly distorted by imprecise and incomplete answers and misleading interpretations of the available information. To minimise the risk of an inaccurate analysis and conclusions, the coffee business expert Kerstin Linne was contacted to review the results of the case study interviews. Overall, she confirmed the research findings, but had also some minor suggestions for improvement. For example, she advised that the two big roasters Tchibo and Nestlé are rated equally in the adaptation step as they carry out similar activities in this stage of organisational learning. Considering the inter-organisational learning projects, she also argued that one SN agent contributed much stronger to the 'AdapCC' project than CIAT. Although she was the sole external expert to provide validation and propose modifications, her advice made a significant contribution to the research. The option of sending a summary of the findings to the interviewees was rejected as a critical self-reflection could not be guaranteed and as time was too limited.
3. Network learning does not require that every agent adapts to climate change, but that as many agents as possible are involved in the learning process. However, the network learning process might be obsolete if organisational learning already allows individual agents to adapt effectively to supply chain climate risk. For that reason, network learning might only be required in supply networks in which the exposed agents are unable to adapt to climate change independently.

12.7 Directions for future research

As the modelled network learning process is based on a single, admittedly multi-organisational case study, further research is required to determine its generalizability. The investigation of further cases would lead to a more robust model as information from multiple networks could

be triangulated to validate and refine the proposed process model. The qualitative analysis in this thesis could also be supplemented by a quantitative investigation involving the collection of more operational, market and financial data. Future research should also test the model in the context of risk sources other than climate change. Additional research could address the proposed mechanisms that facilitate the network learning process. A more explanatory research approach could reveal the cause and effect relationships between the design and implementation of the different mechanisms and their impacts on the quality and success of the network learning process. Such explanatory research could also investigate the cause and effect relationships of network learning in complex adaptive systems.

Finally, more research is also needed to offer more insights into the measures that make a supply network adaptable to climate change. This would focus on physical adaptation measures, such as a return to more localised sourcing and the climate-proofing of logistics infrastructure that must be implemented by the farmers to achieve an overall resilience of the coffee supply network. If current climate projections prove accurate and carbon mitigation efforts continue to fall short of requirement, the adaptation of supply networks to climate change is likely to become a major preoccupation of management during this century.

Appendix

The appendences are attached as electronic files to this thesis (see back of the cover)

Table of content:

References

4C (2013) 4C Association [online] (cited 27th March 2013) available from: <http://www.4c coffeeassociation.org/>

Aastrup, J. And Halldorsson, A. (2008) Epistemological role of case studies in logistics, *International Journal of Physical Distribution & Logistics Management*, Vol. 38, No. 10, pp. 746-763.)

Adams, J. (2000) *Risk*, Routledge, London, UK.

AdapCC (2013) Adaptation for Smallholders to Climate Change [online] (cited 24th July 2013), available from: <http://www.adapcc.org/>

AdapCC (2010) *How can small-scale coffee and tea producers adapt to climate change?*, AdapCC Final Report – Results and Lessons learnt, Eschborn, Germany, 2010.

AdapCC (2008) How can smallholder tea and coffee growers cope with climate change?, *Synthesis Report AdapCC*, Bonn, Germany.

Adaptation Scotland (2013) [online] (citied 03. February 2013) available from: <http://www. adaptationscotland.org.uk/1/1/0/Home.aspx>

Akasofu, S. (2010) On the Recovery from the Little Ice Age, *Natural Science*, Vol. 2, No. 11, 12111224, doi:10.4236/ns.2010.211149

Allen, P.M. and Strathern, M. (2003) Evolution, Emergence, and Learning in Complex Systems. *Emergence*, Vol. 5, No. 4, pp. 8-33.

Alvesson, M. and Skoldberg, K. (1994) *Tolkning och Reflektion – Vetenskapsflilosofi och kvalitativmetod*, Studentlitteratur

Andersen, L. (2001) *Denmark-Vietnam sector program support*, in: Wastewater Reuse in Agriculture in Vietnam, Water Management, Environment and Human Health Aspects. Workshop IWMI.

Argyris, C. (1999) *On Organizational Learning*, 2nd edition, Blackwell Publishers, Oxford.

Argyris, C. and Schön, D.A. (1978) *Organizational Learning: A Theory of Action Perspective*, Addison Wesley, London.

Argyris, C. and Schön, D.A. (1996) *Organizational Learning II: Theory, Method and Practice*, Addison Wesley, London, UK.

Arlbjorn, J.S. and Halldorsson, A. (2002) Logistics knowledge creation: reflection on content, context and processes, *International Journal of Physical Distribution & Logistics Management*, Vol. 32, No. 1, pp. 22-40.

Arlbjorn, J.S., Jonsson, P. and Johansen, J. (2008), Nordic research in logistics and supply chain management: an empirical analysis, *International Journal of Physical Distribution & Logistics Management*, Vol. 38, No. 6, pp. 452-474.

Arnell, N.W. (2004) Climate change and global water resources: SRES emissions and socio economic scenarios, *Global Environmental Change*, Vol. 14, pp. 31 – 52.

Baker, P. (2012) *Coffee & Climate: The Geometry of Change - A Rapid Field Diagnostic of Coffee Farmers' Production Challenges in Cu M'ga district, Dak Lak Vietnam*, for the initiative for Coffee & Climate in cooperation with E.D.E consulting, Hamburg, Germany.

Ballou, R.H. (2007) The evolution and future of logistics and supply chain management, *European Business Review*, Vol. 19, No. 4, pp. 332-348.

Bandyopadhyay, K. Mykytn, P. and Mykytyn, K (1999) A framework for integrated risk management in information technology, *Management Decision*, Vol. 37, No. 5, pp. 437-444.

Benton, T. and Craib, I. (2001) *Philosophy of Social Science: The Philosophical Foundation of Social Thought*, Basingstoke, Palgrave.

Berner, U. and Streif, H. (2004*) Klimafakten: Der Rückblick – Ein Schlüssel für die Zukunft*, 4th edition, Schweizerbart, Stuttgart, Germany.

Bhaskar, R. (2008) *A realist theory of science*, (2nd ed.), Verso, London, UK.

Bhaskar, R. (1998) General introduction, in Archer, M., Bhaskar, R., Collier, A., Lawson, T. and Norrie, A. (Eds), *Critical Realism – Essential Readings*, Routledge, London, pp. 1-15

Bhatt, G.D. (2000a) Organizing knowledge in the knowledge development cycle, *Journal of Knowledge Management*, Vol. 4, No. 1, pp. 15-26.

Bhatt, G.D. (2000b) Information, dynamics, learning and knowledge creation in organizations, *The Learning Organization*, Vol. 7, No. 2, pp. 89-98.

Bierly, P.E., Kessler, E.H. and Christensen, E.W. (2000) Organizational learning, knowledge and wisdom, *Journal of Organizational Change Management*, Vol. 13, No. 6, pp. 595-618.

Bioconsult (2010) *Kurzinformation zum Klimawandel in der Metropolregion Bremen-Oldenburg*, BIOCONSULT Schuchardt & Scholle for nordwest2050, Bremen, Germany.

Blackhurst, J., Craighead, C.W., Elkins, D. and Handfield, R.B. (2005) An empirically derived agenda of critical research issues for managing supply-chain disruption*, International Journal of Production Research*, Vol. 43, No. 19, pp. 4067-4081.

Blos, M.F., Quaddus, M., Wee, H.M. and Watanabe, K. (2009) Supply chain risk management (SCRM): a case study on the automotive and electronic industries in Brazil, *Supply Chain Management: An International Journal*, Vol. 14, No. 4, pp. 247-252.

Brown, F.M.W, Pielke, R.A. and Annan, J.D. (2007) *Survey: Is there agreement among climate scientists on the IPCC AR4 WG1?*, unpublished.

Butner, K. (2010) The smater supply chain in the future, *Strategy & Leadership*, Vol. 38, No. 1, pp. 22-31.

Bryman, A, and Bell, E. (2007) *Business Research Methods*, Oxford University Press, New York, US.

Bui, H. and Baruch, Y. (2010) Creating learning organizations: a systems perspective, *The Learning Organization*, Vol. 17, No. 3, pp. 208-227.

Burrell G. and Morgan G. (1979) *Sociological paradigms and organisational analysis - elements of the sociology of corporate life*, reprint 2005, Ashgate Publishing Ltd, Aldershod, Great Britain.

Cafédirect (2012) *Committed to our Gold Standard – Annual Review 2011*, London.

CARE International (2012) Participatory Monitoring, Evaluation, Reflection and Learning for Community based, *Adaptation: A Manual for Local Practitioners*, pp. 88.

Castaneda, D.I. and Rios, M.F. (2008) From Individual Learning to Organizational Learning, *The Electronic Journal of Knowledge Management*, Vol. 5, No. 4, pp. 363-372.

Cavinato, J.L. (2004) Supply chain logistics risks – from the back room to the board room, *International Journal of Physical Distribution & Logistics Management*, Vol. 34, No. 5, pp. 383-387.

Cavinato, J.L. (1992) A total cost/value model for supply chain competitiveness, *Journal of Business Logistics*, Vol. 13, No. 2, pp. 285-301.

CCSP (2009) Coastal Sensitivity to Sea Level Rise: A Focus on the Mid-Atlantic Region, A report by the U.S. Climate Change Science Program and the Subcommittee in Global Change Research. [Titus, J.G. (Coordinating Lead Author), Anderson K.E., Cahoon D.R., Gesch D.B., Gill S.K., Gutierrez B.T., Thieler E.R. and Williams S.J. (Lead Authors)], U.S. Environmental Protection Agency, Washington D.C., USA.

Chapman, L (2007) Transport and climate change: a review, *Journal of Transport Geography*, Vol. 15, pp. 354-367.

Chapman, P., Christopher, M., Jüttner, U., Peck, H. and Wilding, R. (2002) Identifying and Managing Supply-Chain Vulnerability, *Logistics & Transport Focus*, Vol. 4, No. 4, pp. 59 64.

Cheng, S.K. and Kam, B.H. (2008) A conceptual framework for analyzing risk in supply networks, *Journal of Enterprise Information Management*, Vol. 22, No. 4, pp. 345-360.

Choi, T.Y., Dooley, K.J. and Rungtusanatham, M. (2001) Supply networks and complex adaptive systems: control versus emergence, *Journal of Operations Management*, Vol. 19, No. 3, pp. 351-366.

Chopra, S. and Sodhi, M.S. (2004) Managing risk to avoid supply-chain breakdown, *MIT Sloan Management Review*, Vol. 46, No. 1, pp. 52-61.

Christopher, M. (2005) *Logistics and Supply Chain Management*, 3rd Edition, Harlow, Prentice Hall.

Christopher, M. (2000) The Agile Supply Chain: Competing in Volatile Markets*, Industrial Marketing Management*, Vol. 29, No. 1, pp. 37-44.

Christopher, M. (1998*) Logistics and Supply Chain Management: Strategies for reducing cost and improving service*, 2nd Edition, Financial Times Publishing, London.

Christopher, M. (1992) *Logistics: The Strategic Issues*, Chapman & Hall, London.

Christopher, M. and Holweg, M. (2011). "Supply Chain 2.0": managing supply chains in the era of turbulence*, International Journal of Physical Distribution & Logistics Management*, 41**,** 63-82.

Christopher, M. and Lee, H. (2004) Mitigating supply chain risk through improved confidence, *International Journal of Physical Distribution & Logistics Management*, Vol. 34, No. 5, pp. 388-396.

Christopher, M. and Peck, H. (2004a) Building the Resilient Supply Chain, *The International Journal of Logistics Management*, Vol. 15, No. 2, pp. 1-13.

Christopher, M. and Peck, H. (2004b) The five principles of supply chain resilience, *Logistics Europe*, Vol. 12, No. 1, pp. 16-21.

Christopher, M. and Rutherford, C. (2004) *Creating Supply Chain Resilience Through Agile Six Sigma*, CriticalEYE Publications, June – August 2004.

Christopher, M., Lowson, R., and Peck, H. (2004) "Creating agile supply chains in the fashion industry", *International Journal of Retail & Distribution Management*, Vol. 32, No 8, pp. 367-369.

CIAT (2012) *Future Climate Scenarios for Viet Nam's Robusta growing areas*, Final report, Cali, Colombia, 2012.

CIAT (2010) *Coffee growing suitability maps for the Baragwi region*, in: Climate Change Adaptation and Mitigation in the Kenyan Coffee Sector, Guide Handbook – Sangana PPP – 4C Climate Module, GIZ, Eschborn, 2011.

CIAT (2009) *Impact of Progressive Climate Change in AdapCC Coffee Project Areas*, CIAT.

Coffee & Climate (2013) *Coffee & Climate – enabling effective responses* [online] (cited 15th May 2013), available from: <http://www.coffeeandclimate.org/>

Collies, J. And Hussey, R. (2009) *Business Research – A practical guide for undergraduate & postgraduate students,* (3rd ed.), Palgrave, UK.

Cooper, M.C. and Ellram, L.M. (1993) Characteristics of supply chain management and the implications for purchasing and logistics strategy, *International Journal of Logistics Management*, Vol. 4, No. 2, pp. 13-24.

Cooper, M.C., Lambert, D.M., Pagh, J.D. (1997) Supply Chain Management: More Than a New Name for Logistics, *The International Journal of Logistics Management*, Vol. 8, No. 1, pp. 1-14.

Council of Logistics Management (CLM) (1998) *What It's All About*, Vol. 4, No. 6., Oaks Brook, IL, US.

Cox, A. (1999) Power, value and supply chain management, *Supply Chain Management: An International Journal*, Vol. 4, No. 4, pp. 167-175.

Craighead, C.W., Blackhurst, J., Rungtusanatham, M.J. and Handfield, R.B. (2007) The Severity of Supply Chain Disruptions: Design Characteristics and Mitigation Capabilities, *Decision Sciences*, Vol. 38, No. 1, pp. 131-156.

Crossan, M.M., Lane, H.W. and White, R.E. (1999) An Organizational Learning Framework: From Intuition to Institution, *Academy Of Management Review*, Vol. 24, No. 3, pp. 522 537.

Crossan, M.M., Lane, H.W. and White, R.E., and Djurfeldt, L. (1995) Organizational Learning: Dimensions for a theory, *The International Journal of Organizational Anaylsis*, pp. 337 360.

Crotty, M. (1998) *The Foundation of Social Research. Meaning and Perspective in the Research Process*, Sage Publications, London, U.K.

CSCMP (2011) Council of Supply Chain Management Professionals [online] (cited 2nd February 2011), available from: <http://cscmp.org/aboutcscmp/definitions.asp>.

Danermark, B. (2001) *Explaining Society: An Introduction to Critical Realism in the Social Sciences*, Routledge, Florence, KY.

Datta, P.P. (2007) *A Complex System, Agent Based Model for Studying and Improving the Resilience of Production and Distribution Networks* (unpublished PhD thesis), Cranfield University, UK.

Davis, J.P., Eisenhardt, K.M. and Bingham, C.B. (2009) Optimal Structure, Market Dynamisn, and the Strategy of Simple Rules, *Administrative Science Quarterly*, Vol. 54, pp. 413-452.

Denzin, N.K. (2006) *Sociological Methods – A Sourcebook*, 5th ed, Transaction Publishers, New Jersey, US.

Denzin, N. and Lincoln Y. (1994) Introduction: entering the field of qualitative research, *Handbook of Qualitative Research*, Sage Publications, pp. 1-17, London, UK.

Desai, D.A. (2010) Co-creating learning: insights from complexity theory, *The Learning Organization*, Vol. 17, No. 5, pp. 388-403.

De Bruin, K., Dellink, R.B., Ruijs, A., Bolwidt, L., van Buuren, A., Graveland, J., de Groot, R.S., Kuikman, P.J., Reinhard, S., Roetter, R.P., Tassone, V.C., Verhagen, A., van Ierland, E.C. (2009), Adapting to climate change in The Netherlands: an inventory of climate adaptation options and ranking of alternatives, *Climate Change*, Vol. 95, pp. 23-45.

De Vries, T. (2013) *IDH –The Sustainable Trade Initiative*, [online] (cited 25th June 2013), available from: <http://www.idhsustainabletrade.com/coffee>.

De Wart, D. (2006) Getting SMART about Risk Management, *Supply Chain Management Review*, Vol. 10, No. 8, pp. 27-33.

Dictionary (2013) *Definition of pre-competitive*, [online] (cited 29th July 2013), available from: <http://dictionary.reference.com/browse/precompetitive>.

Dixon, N.M. (1994) The *Organizational Learning Cycle. How We Can Learn Collectively*, McGraw Hill, London/New York.

Dubois, A. and Gadde, L.E. (2002) Systematic combining: an abductive approach to case research, *Journal of Business Research*, Vol. 55, No. 7, pp. 553-560.

Dynes, R.R. (2003) Noah and Disaster Planning: The Cultural Significance of the Flood Story, *Journal of Contingencies and Crisis Management*, Vol. 11, No. 4, pp. 170-177.

Easterby-Smith, M., Thorpe, R. and Jackson, P.R. (2008) *Management Research*, (3rd ed.), Sage Publishing, London.

Ebers, M. (1997) Explaining inter-organizational network formation, in: *The Formation of Inter Organizational Networks*, Ebers, M. (ed), Oxford University Press.

Ecom (2013a) *The Coffee Product Supply Chain* [online] (cited 27th April 2013) available from: <http://www.ecomtrading.com/en/our-products/coffee/about-ecom-coffee114.html>

Ecom (2013b) [online] (cited 27th April 2013) available from <http://www.ecomtrading.com/>

Ecom (2011) *Ecom Sustainability Overview*, Ecom Agroindustrial Corporation Ltd, Pully, Switzerland, 2011.

EEA (2008) *Impacts of Europe's changing climate – 2008 indicator-based assessment,* EEA, Copenhagen, Denmark.

Ellram, L.M. (1996) The use of the case study method in logistics research, *Journal of Business Logistics*, Vol. 17, No. 2, pp. 93- 138.

Ellram, L.M., Tate, W. and Carter, C. (2007) Product-process-supply chain: an integrative approach to three dimensional concurrent engineering, *International Journal of Physical Distribution & Logistics Management*, Vol. 37, No. 4, pp. 306-330.

Eisenhardt, K.M. (1989) Building Theories from Case Study Research, *Academy of Management Review*, Vol. 14, No. 4, pp. 532-550.

Espinosa, A. and Porter, T. (2011) Sustainability, complexity and learning: insights from complex systems approaches, *The Learning Organisation*, Vol. 18, No. 1, pp. 54-72.

ETP (2012) *Ethical Tea Partnership* [online] (cited 23. December 2012), available <http://www.ethicalteapartnership.org/about/>

Fairtrade (2013) *Climate Change and Fairtrade – Why is it time to make the links*, Fairtrade International (FLO), Bonn.

Fernie, J., Sparks, L. and McKinnon, A.C. (2010) Retail logistics in the UK: past, present and future, *International Journal of Retail & Distribution Management*, Vol. 38, No. 11/12, pp. 894-914.

Finch, P. (2004) Supply chain risk management, *Supply Chain Management: An International Journal*, Vol. 9, No. 2, pp. 183-196.

Fiol, C.M. and Lyles, M.A. (1985) Organizational Learning, *Academy of Management Review*, Vol. 10, No. 4, pp. 803-813.

Fulmer, R.M. and Keys, J.B. (2004) A conversation with Chris Argyris: the father of organizational learning in: Starkey, K., Tempest, S. and McKinlay, A. (2004) *How Organizations Learn Managing the search for Knowledge*, 2nd ed, Thomson Learning, London, UK.

Gammelgaard, B. (2003) Schools in logistics research, *International Journal of Physical Distribution & Logistics Management*, Vol. 34, No. 6, pp. 479-491.

Garavan, T. (1997) The learning organization: a review and evaluation, *The Learning Organization*, Vol. 4, No. 1, pp. 18-29.

Gaudenzi, B. and Borghesi, A. (2006) Managing risks in the supply chain using the AHP method, *The International Journal of Logistics Management*, Vol. 17, No. 1, pp. 114-136.

Gibson, B.J., Mentzer, J.T. and Cook, R.L. (2005) Supply chain management: The pursuit of a consensus definition, *Journal of Business Logistics*, Vol. 26, No. 2, pp. 17-25.

Giunipero, L.C. and Eltantawy, R.A. (2004) Securing the upstream supply chain: a risk management approach, *International Journal of Physical Distribution & Logistics Management*, Vol. 34, No. 9, pp. 698-713.

GIZ (2013a) *Deutsche Gesellschaft für International Zusammenarbeit* (GIZ) GmbH [online](cited 4th March 2013) available from: <http://www.giz.de/>.

GIZ (2013b) *Rural development – Agriculture and Climate Change*, Advisory Service of GIZ, Bonn, Germany.

Golicics, S.L., Davis, D.F. and McCarthy T.M. (2005) A Balanced Approach to Research in Supply Chain Management, in: Kotzab H., Seuring, S., Müller, M., and Reiner, G. (Eds) *Research Methodologies in Supply Chain Management*, Physica Verlag, Heidelberg.

Goodwin, P. and Wright, G. (2009) *Decision Analysis for Management Judgement*, 4th ed., Wiley Publications, UK.

Greening, P. (2010) Supply chain futures: the mastery of complexity, *Manufacturing and Logistics IT* [online] (cited 15. August 2012) available from: <http://www.logisticsit.com/absolutenm/templates/artcle-critical.aspx?articleid=5121&zoneid=31>

GTZ (2012) *Adapting Urban Transport to Climate Change –Modul 5f*, GTZ – Transport Policy Advisory Services, Bonn, Germany.

Guba, E. (1990) *The Paradigm Dialog*, Newbury Park, Sage Publications

Haggar, J. (2011) *What does research tell us about climate change and coffee?*, presentation at Coffee and Climate Conference, Lausanne, 2011.

Halldorsson, A. and Kovacs, G. (2010) The sustainable agenda and energy efficiency, *International Journal of Physical Distribution & Logistics Management*, Vol. 40, No. 1/2, pp. 5-13.

Hallikas, J., Karvonenm, I., Pulkkinen, U., Virolainen, V.M., and Tuominen, M. (2004) Risk management processes in supplier networks*, International Journal of Production Economics*, Vol. 90, No.1, pp. 47-58.

Harland, C., Brenchley, R. and Walker, H. (2003) Risk in supply networks, *Journal of Purchasing & Supply Management*, Vol. 9, pp. 51-62.

Hanson, S., Nicholls, R. J., Hallegatte, S. and Corfee-Morlot, J. (2010) *The Effects of Climate Mitigation on The Exposure of Worlds Large Port Cities To Extreme Coastal Water Levels*, Storm Surge Congress, 13-17 September 2010, Hamburg.

Hanson, S., Nicholls, R., Ranger, N., Hallegatte, S., Corfee-Morlot, J., Herweijer, C. and Chateau, J. (2009) An Assessment of the Exposure of Large Port Cities to Coastal Flooding: A Global Assessment, Land-Ocean Interactions in the Coastal Zone, *LOICZ Inprint,* No. 2, pp. 3-6.

Haugh, H.M. and Talwar, A. (2010) How Do Corporations Embed Sustainability Across the Organization, *Academy of Management Learning & Education*, Vol. 9, No. 3, pp. 384 396.

Hauser, L. M. (2003) Risk-Adjusted Supply Chain Management, *Supply Chain Management Review*, Vol. 7, No, 6, pp. 64-71.

Hearnshaw, E.J.S. and Wilson, M.M.J. (2011) A complex network approach to supply chain network theory, *International Journal of Operations & Production Management*, Vol. 33, No. 4, pp. 442-469.

Hedberg, B. (1981) *How organizations learn and unlearn?* in: P.C. Nystrom &W.H. Starbuck (Eds.), Handbook of organizational design, pp. 8-27, Oxford University Press, London.

Hendricks, K.B. and Singhal, V,R. (2005) An Empirical Analysis of the Effect of Supply Chain Disruption on Long-Run Stock Price Performance and Equity Risk of the Firm, *Production and Operations Management*, Vol. 14, No. 1, pp. 35-52.

Highway Agency (2011) *Climate Change Risk Assessment*, Highway Agency is an executive agency for the Department of Transport, United Kingdom.

Hilmoa, O.P.; Hejazi, A. and Ojala, L. (2005) Supply chain management research using case studies: a literature review, *International Journal of Integrated Supply Management*, Vol. 30, No. 3, pp. 294-311.

Hinkel, J. and Klein, R.J.T. (2009) Integrating knowledge to assess coastal vulnerability to sea level rise: The development of the DIVA tool, *Global Environmental Change*, Vol. 19, pp. 384 – 395.

Holmqvist, M. (1999) Learning in imaginary organizations: creating interorganizational knowledge, *Journal of Organizational Change Management*, Vol. 12, No. 5, pp. 419-438.

Holste, J.S. and Fields, D. (2010) Trust and tacit knowledge sharing and use, *Journal of Knowledge Management*, Vol. 14, No. 1, pp. 128-140.

Hyde, K.F. (2000) Recognising deductive processes in qualitative research, *Qualitative Market Research: An International Journal*, Vol. 3 No. 2, pp. 82-90.

Johnson, C. (1996) Deductive versus inductive reasoning: a closer look at economics, *Social Science Journal*, Vol. 33, No. 3, pp. 287-99.

ICO (2013) *International Coffee Organization* [online] (cited 29th April 2013) available from: <http://www.ico.org/index.asp>

IDH (2013) The Sustainable Trade Initiative [online] (cited 23. July 2013), available from: <http://www.idhsustainabletrade.com/>.

IPCC (2007a) *Mitigation of Climate Change*, Working Group III Fourth Assessment Report, Geneva, Switzerland.

IPCC (2007b) *Glossary of Terms*, Annex B to IPCC Fourth Assessment Report: Climate Change 2007 (AR4)

IPCC (2007c) *Climate Change 2007: Synthesis Report. Contribution of Working Groups I,II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*

[Core Writing team, Pachauri, R.K and Reisinger, A. (eds.)], IPCC, Geneva, Switzerland.

IPCC (2000) *Emission Scenarios – A Special Report of IPCC Working Group III*, IPCC, Geneva, Switzerland.

Juttner, U. (2005) Supply chain risk management – Understanding the business requirements from a practitioner perspective, *The International Journal of Logistics Management*, Vol. 16, No. 1, pp. 120-141.

Juttner, U., Peck, H. and Christopher, M. (2003) Supply chain risk management: outlining an agenda for future research, *International of Journal of Logistics: Research & Applications*, Vol. 6, No. 4, pp. 197-210.

Kaufmann, S. (1995) *At Home in the Universe*, Oxford University Press, New York

Kleindorfer, P.R. and Saad, G.H. (2005) Managing Disruption Risks un Supply Chains, *Production and Operations Management*, Vol. 14, No. 1, pp. 53-68.

Kim, D.H. (2004) The Link between Individual Learning and Organizational Learning, in: Starkey, K., Tempest, S. and McKinlay, A. (2004) *How Organizations Learn – Managing the search for Knowledge*, 2nd ed, Thomson Learning, London, UK.

Kim, D.H. (1993) The Link between Individual Learning and Organizational Learning, *Sloan Management Review*, Fall (35:1), pp. 37-50.

Knight, F.H. (1921) *Risk, Uncertainty and Profit*, Signalman Publishing, Kissimmee, U.S.

Knight, L. (2002) Network Learning: Exploring learning by interorganizational networks, *Human Relations*, Vol. 55, No. 4, pp. 427-453.

Knight, L. (2000) Learning to Collaborate: A study of individual and organizational learning, and interorganizational relationships, *Journal of Strategic Marketing*, Vol. 8, pp. 121-138.

Knight, L. and Harland, C.M. (2005) Managing Supply Networks: Organizational roles in network management, *European Management Journal*, Vol. 23, No. 3, pp. 281-292.

Knight, L. and Harland, C.M. (2001) Supply Network Strategy. Role and Competence Requirements, *International Journal of Operations and Production Management*, Vol. 21, No. 4, pp. 476-489.

Knight, L. and Pye, A. (2005) Network Learning: an empirically-derived model of learning by groups of organizations, *Human Relations*, Vol. 58, No. 3, pp. 369-392.

Knight, L. and Pye, A. (2005) Exploring the relationships between network change and network learning, *Human Relations*, Vol. 35, No. 4, pp. 473-490.

Koetse, M.J. and Rietveld, P. (2009) The impact of climate change and weather on transport: An overview of empirical findings, *Transportation Research part D*, Vol. 14, p. 205-221.

Kovacs, G., and Spens, K.M. 2005, Abductive Reasoning in Logistics Research, *International Journal of Physical Distribution& Logistics Management*, Vol. 35, No. 2, pp. 132-144.

Kuhn, T.S (1962) *The Structure of Scientific Revolutions*, 50th Anniversary Edition 2012, University of Chicago Press. U.S.

Larson, P.D., and Halldorsson, A. (2004) Logistics Versus Supply Chain Management: An International Survey, *International Journal of Logistics: Research and Applications*, Vol. 7, No. 1, pp. 17-31.

Lee, H.L. (2004) The triple-A supply chain, *Harvard Business Review*, Vol. 82, No. 10, pp. 102 112.

Lenton, T.M., Held, H., Kriegler, E., Hall, J.W., Lucht, W., Rahmstorf, S., Schellnhuber, H.J. (2008) Tipping elements in the Earth's climate system, *PNAS* 105, 1786.

Lucas, L.M. (2010) The evolution of organizations and the development of appropriate knowledge structures, *Journal of Knowledge Management*, Vol. 14, No. 2, pp. 190-201.

Lummus, R. and Vokurka, R.J. (1999) Defining supply chain management: a historical perspective and practical guidelines, *Industrial Management & Data Systems*, Vol. 99, No. 1, pp. 11-17.

Lummus, R., Krumwiede, D. And Vokurka, R. (2001) The relationship of logistics to supply chain management: developing a common industry definition, *Industrial Management & Data Systems*, Vol. 101, No. 8, pp. 426-432.

Lyubimov, A. (2011) Critical realism theory [online] (cited 17th April 2011) available from: http://istheory.byu.edu/wiki/ Critical_realism_theory.

Macbeth, D.K., Halldorsson, A., Murphy, M. and Wildgoose, N. (2009) *Supply chain disruption - risks and event database*, The Partner, May, pp. 38-41.

Mangan, J. And Christopher, M. (2005) Management development and the supply chain manager of the future, *The International Journal of Logistics Management*, Vol. 19, No. 2, pp. 178-191.

Manuj, I. and Mentzer, J.T. (2008) Global supply chain risk management strategies, *International Journal of Physical Distribution & Logistics Management*, Vol. 38, No. 2, pp. 192-223.

March, J.G. and Shapira, Z. (1987) Managerial perspectives on risk and risk taking, *Management Science*, Vol. 33, 1404-1418.

Marsh, A. (2007) *Diversification by Smallholder Farmers: Viet Nam Robusta Coffee*, Food and Agriculture Organizations of the United Nations (FAO).

Martha, J. and Subbakrishna, S. (2002) Targeting a Just-In-Case Supply Chain for the inevitable next Disaster, *Supply Chain Management Review*, Vol. 6, No. 5, pp. 18-24.

Mason-Jones, R., Naylor, B. & Towill, D.R. (2000). Engineering the leagile supply chain. *International Journal of Agile Management Systems,* 2**,** 54-61.

Mastermann, M. (1970) The nature of paradigm, in: Lakatos, I. And Musgrave, A. (eds), *Criticism and the Growth of Knowledge*, Cambridge University Press, pp. 59-89.

McElroy, M.W. (2000) Integrating complexity theory, knowledge management and organizational learning, *Journal of Knowledge Management*, Vol. 4, No. 3, pp. 195 203.

McGrath, J.E. (1982) 'Dilemmatics: The Study of Researcj Choices and Dilemmas' in *Judgement Calls in Research,* McGrath, J.E., Martin, J., Kula, R. [eds.], Sage Publications, U.S.

McKean, T., Meade, C., Watkins, B., Richison, T. and Goodson, B. (2007) Lessons from Recent Natural Disasters, *Municipal Finance Journal*, Vol. 27, No. 4, p. 27.

McKinnon, A.C (2013) 'Adapting Logistical Systems To Climate Change: The Challenges Ahead', in: *Outlook of the Logistics & Supply Chain Industry 2013*, World Economic Forum - Global Agenda Council on Logistics & Supply Chain Systems 2012-2014, Geneva, Switzerland, 2013.

McKinnon, A.C. (2012) 'Environmental sustainability: a new priority for logistics managers' in: McKinnon, A.C., Cullinane, S., Browne, M., and Whiteing, A. (eds) (2012) *Green Logistics – Improving the environmental sustainability of logistics*, 2nd ed, Kogan Page Ltd.

Mentzer, J.T. and Flint, D.J. (1997) Validity in logistics research, *Journal of Business Logistics*, Vol. 18, No. 1, pp. 199-216.

Mentzer, J.T. and Kahn, K.B. (1995) A framework of logistics research, *Journal of Business Logistics*, Vol. 16, No. 1, pp. 231-250.

Mentzer, J.T., De Witt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D. and Zacharia, Z.G (2001) Defining supply chain management, *Journal of Business Logistics*, Vol. 22, No 2, pp. 1-15.

Miles, R.H. and Randolph, W.A. (1980) Influence of organizational learning styles on early development. In J.H. Kimberly and Robert H. Miles and Associates, (Eds.), *The organizational life cycle*, pp. 44-82, San Francisco, U.S.

Mishra, B. And Bhaskar, U. (2010) Knowledge management process in two learning organisations, *Journal of Knowledge Management*, Vol. 15, No. 2, pp. 344-359.

Mitchell, V.W. (1995) Organizational Risk Perception and Reduction: A Literature Review, *British Journal of Management*, Vol. 6, pp. 115-133.

Montuori, L.A. (2000) Organizational longevity, *Journal of Organizational Change Management*, Vol. 13, No. 1, pp. 66-73.

Morgan, G. and Smircich, L. (1980) The case for qualitative research, *Academy of Management Review*, Vol. 5, No. 4, pp. 491-500.

Naslund, D. (2002) Logistics needs qualitative research – especially action research, *International Journal of Physical Distribution & Logistics Management*, Vol. 32, No. 5, pp. 321 – 338.

Nescafé (2013) *The NESCAFÉ Plan*, [online] (cited 21. April 2013) available from: <http://www.n escafe.com/farming_en_com.axcms?ActiveID=1250>

Nestlé (2012) *Annual Report 2012*, Cham and Vevey, Switzerland.

Nicholls, R.J. and Tol, R.S.J. (2006) Impacts and responses to sea-level rise: over a global analysis of the SRES scenarios over the twenty-first century, *Philosophical Transactions of The Royal Society A*, 364, 1073-1095.

Nilsson, F. (2003) *A Complex Adaptive System Approach in Logistics*, Division of Packaging Logistics, Lund University, Lund.

Nilsson, F. and Gammelgaard (2012) Moving beyond the systems approach in SCM and logistics research, *International Journal of Physical Distribution & Logistics Management*, Vol. 42, No. 89, pp. 764-783.

Nilsson, F. and Darley, V. (2006) on complex adaptive systems and agent-based modeling for improving decision-making in manufacturing and logistics setting*, International Journal of Operations & production Management*, Vol. 26, No. 12, pp. 1351-1373.

NOAA, US National Oceanic and Atmospheric Administration (2009) *State of the Climate Report*, Ashville, UK.

Nonaka, I. (2004) A dynamic theory of organizational knowledge creation, in: Starkey, K., Tempest, S. and McKinlay, A. (2004) *How Organizations Learn – Managing the search for Knowledge*, 2nd ed, Thomson Learning, London, UK.

Nonaka, I. (1991) The Knowledge creating company, *Harvard Business Review*, Vol. 69, No. 6, pp. 96-104.

Nonaka, I. And von Krogh, G. (2009) Tacit Knowledge and Knowledge Conversion: Controversy and Advancement in Organizational Knowledge Creation Theory, *Organization Science*, Vol. 20, No. 3, pp. 635-652.

Norrman, A. and Jansson, U. (2004) Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident, *International Journal of Physical Distribution & Logistics Management,* Vol. 34, No. 5, pp. 434-456.

Nyambura, J. (2012) *Climate change training well received by farmers and local communities*, ETP, [online] (cited 23. December 2012), available from: <http://www.ethicalteapa

rtnership.org/blog/climate-changetraining-well-received-by-farmers-and-localcommunities/>

Örtenblad, A. (2004) The learning organization: towards an integrated model, *The Learning Organization*, Vol. 11, No. 2, pp. 129-144.

Örtenblad, A. (2001) On differences between organizational learning and learning organization, *The Learning Organization*, Vol. 8, No. 3, pp. 125-134.

Palmberg, K. (2009) Complex adaptive systems as metaphors for organizational management, *The Learning Organization*, Vol. 16, No. 6, pp. 483-498.

Palombo, S. (1999) *The Emergent Ego: Complexity and Coevolution in the Psychoanalytic Process*, International Universities Press, Madison, WI, US.

Pathak, S.D., Day, J.M., Nair, A., Sawaya, W.J. and Kristel, M.M. (2007) Complexity and Adaptivity in Supply Networks: Building Supply Network Theory Using a Complex Adaptive Systems Perspective, *Decision Sciences*, Vol. 38, No. 4, pp. 547-580.

Patton, M.Q. (2002) Qualitative research and evaluation methods, (3rd ed.), Sage Thousand Oaks, U.S

Peck, H. (2007) Supply Chain Vulnerability, Risk and Resilience, in: Waters, D. (ed.), *Global Logistic New Directions in Supply Chain Management*, 5th ed., pp. 223-237.

Peck, H. (2006) Reconciling supply chain vulnerability, risk and supply chain management, *International Journal of Logistics: Research and Application*, Vol. 9, No. 2, pp. 127-142.

Peck, H. (2005) Drivers of supply chain vulnerability: an integrated framework, *International Journal of Physical Distribution & Logistics Management*, Vol. 35, No. 4, pp. 210-232.

Pena, I. (2002) Knowledge networks as part of an integrated knowledge management approach, *Journal of Knowledge Management*, Vol. 6, No. 5, pp. 469-478.

Perry, M. (2007) Natural disaster management planning, *International Journal of Physical Distribution & Logistics Management*, Vol. 37, No. 5, pp. 409-433.

Pfeffer, W.T., Harper, J.T, and Neel, S.O. (2008) Kinematic Constraints on Glacier Contribution to 21st Century Sea-Level Rise, *Science*, Vol. 321, pp. 1340-1343.

Pfohl, H.C., Köhker, H, and Thomas, D. (2010) State of the art in supply chain risk management research: empirical and conceptual findings and a roadmap for the implementation in practice, *Logistics Research*, Vol. 2, pp. 33-44.

Piecyk, M.I. (2010) *Analysis of Long term Freight Transport, Logistics, and Related Co2 Trends on a Business-as-Usual bases*, PhD Thesis, School of Management and Languages, Heriot-Watt University, Edinburgh, U.K.

Polanyi, M. (1967), *The Tacit Dimension*, Doubleday, New York, NY., US.

Ponomarov, S.Y. and Holcomb, M.C. (2009) Understanding the concept of supply chain resilience, *The International Journal of Logistics Management*, Vol. 20, No. 1, pp. 124 143.

Prahalad, C.K. and Hamel, G. (1990) The competence of a corporation, *Havard BusinessReview*, May-June, pp. 79-91.

Prater, E., Biehl, M. and Smith, M.A. (2001) International supply chain agility – Tradeoffs between flexibility and uncertainty, *International Journal of Operations & Production Management*, Vol. 21, No. 5, pp. 823-839.

Producersfoundation (2012) [online] (cited 27th December) available from: <http://www.producersfoundation.org/>

Pujawan, N.I. and Geraldin, L.H. (2009) House of risk: a model for proactive supply chain risk management, *Business Process Management Journal*, Vol. 15, No. 6, pp. 953-967.

Pun, K.F. and Nathai-Balkisson, M. (2011) Integrating knowledge management into organizational learning, *The Learning Organization*, Vol. 18, No. 3, pp. 203-223.

Quaffee (2013) *Arabica – The King of Coffee* [online] (citied 29th April 2013) available from: <http://www.quaffee.co.za/Pages/xtras/ArabicaVSRobusta.aspx>

Rahmstorf, S. (2007) A semi-empirical approach to projecting future sea level rise, *Science*, Vol. 315-368.

Rainforest Alliance (2013) [online] (cited 26th March 2013) available from: <http://www.rainforestalliance.org/about>.

Rao, S. and Goldsby, T.J. (2009) Supply chain risks: a review and typology, *The International Journal of Logistics Management*, Vol. 20, No. 1, pp. 9-123.

Rice, J.B. and Caniato, F. (2003) Building a secure and resilient supply network, *Supply Chain Management Review*, Vol. 7 No. 5, pp. 22-30.

Riege, A., (2003) Validity and Reliability Tests in Case Study Research: A Literature Review With "Hands-on" Applications for Each Research Phase. *Qualitative Market Research*, 6 (2) 75-86.

Ritchie, B. and Brindley, C. (2007) Supply chain risk management performance, *International Journal of Operations & Production Management,* Vol. 27, No. 3, pp. 303-322.

Ritchie, B. and Marshall, D. (1993) *Business Risk Management*, Chapman & Hall, London, UK.

Rogelj, J., Nabel, J., Chen, C., Hare, W., Markmann, K., Meinshausen, M., Schaeffer, M., Macey, K., and Hohne, N. (2010) Copenhagen Accord pledges are paltry, *Nature*, 464, 1126 1128

Royal Society (1992) *Risk: Analysis, Perception and Management*, London, UK.

Royal Society (1983) *Risk Assessment: A Study Group Report,* London, UK.

Samuel, D. (1997) Research methods explored: an international-based approach, *Proceeding of the Logistics Research Network Conference*, Huddersfield.

Sanchez, R. (2004) 'Tacit Knowledge' vs. 'Explicit Knowledge' Approaches to Knowledge Management Approaches, *Department of Industrial Economics and Strategy*, Copenhagen Business School, Denmark.

Sangana PPP (2011) Minutes to presentations, *Conference on Climate Change and Coffee - Sangana PPP*, Lausanne, 29th September 2011.

Sayer, A. (2000) *Realism and Social Science*, Sage, London, UK.

Scafetta, N. and West, B.J. (2007) Phenomenological reconstructions of the solar signature in the Northern Hemisphere surface temperature records since 1600, *Journal of Geophysical Research*, Vol. 12, D24S03, doi:10.1029/2007JD008437.

Schneider, R.O. (2011) Climate change: an emergency management perspective, *Disaster Prevention and Management*, Vol. 20, No. 1, pp. 53-62.

Schuchardt, B. and Wittig, S. (2010) *Arbeitspapier: Die Nordwest2050-Klimaszenarien, Herleitung und Vorschlag*, BIOCONSULT Schuchardt & Scholle, Bremen, Germany.

Scot, W.R. (1987) *Organizations: Rational, Natural, and Open Systems*, Prentice-Hall, Englewood Cliffs, NJ, US.

Senge, P.M. (2004) The leader's new work: building learning organizations, in: Starkey, K., Tempest, S. and McKinlay, A. (2004) *How Organizations Learn – Managing the search for Knowledge*, 2nd ed, Thomson Learning, London, UK.

Senge, P.M. (1990) *The Fifth Discipline: The Art and Practice of the Learning Organization*, 2nd edition, Doubleday, New York, US.

Seuring, S. (2008) Assessing the rigor of case study research in supply chain management, *Supply Chain Management: An International Journal*, Vol. 13, No. 2, pp. 128-137.

Seuring, S. (2005) Case study research in supply chains – an outline and three examples, in Kotzab, H., Seuring, S., Mueller, M., and Reiner, G. (Eds), *Research Methodologies in Supply Chain Management*, Physica Verlag, Heidelberg, pp. 235-250.

Sham, C. (2007) An exploratory study of corporate universities in China, *Journal of Workplace Learning*, Vol. 19, No. 4, pp. 257-264.

Sheffi, Y. and Rice, J.B. (2005) A Supply Chain View of the Resilient Enterprise, MIT *Sloan Management Review*, Vol. 47, No. 1, pp. 40-48.

Silverman, D. (1993) *Interpreting Qualitative Data – Methods for Analysing Talk, Text, and Interaction*, Sage Publications, London, UK.

Simon, H.A. (1991) Bounded Rationality and Organizational Learning, *Organization Science*, Vol. 2, No. 1, pp. 125-134.

Sinha, P.R., Whiteman, L.E. and Malzahn, D. (2004) Methodology to mitigate supplier risk in an aerospace supply chain, *Supply Chain Management: An International Journal*, Vol. 9, No. 2, pp. 154-168.

Smit B, Pilifosova O, Burton I, Challenger B, Huq S, Klein R, Yohe G (2001) *Adaptation to climate change in the context of sustainable development and equity.* In: McCarthy JJ, Canziani OF, Leary NA, Dokken DJ, White KS (eds) Climate change 2001: impacts, adaptation, vulnerability. Contribution of working group II to the third assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, pp. 877-912

Smith. P.A.C. (2011) Elements of organizational sustainability, The Learning Organisation, Vol. 18, No. 1, pp. 5-9.

Snover, A.K., Whitely Binder, L., Lopez, J., Willmot, E., Kay, J., Howell, D., Simmonds, J. (2007) *Preparing for Climate Change: A Guidebook for Local, Regional and State Governments*. In association with and published by ICLEI – Local Government for Sustainability, Oakland, CA, U.S.

Solem, O. (2003) Epistemology and logistics: a critical overview, *Systemic Practice and Action Research*, Vol. 16, No. 6, pp. 437-454.

Sommerkorn, M. and Hassol, S.J. (2009) *Arctic Climate Feedbacks: Global Implications*, WWF International Arctic Programme.

Sotirakou, T. and Zeppou, M. (2004) The MATE model: a strategic knowledge management technique on the chessboard of public-sector modernization, *Management Decision*, Vol. 42, No. 1, pp. 69-88.

Sova, C.A., Chaudhury, A.S., Helfgott, A., Corner-Dolloff, C. (2012) *Community-based adaptation costing: An integrated framework for the participatory costing of community-based adaptations to climate change in agriculture,* Working Paper No. 16. Cali, Colombia: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Spekman, R.E. and Davis, E.W. (2004) Risky business: expanding the discussion on risk and the extended enterprise, *International Journal of Physical Distribution & Logistics Management*, Vol. 34, No. 5, pp. 414-433.

Srivastava, P. and Frankwick, G.L. (2011) Environment, management attitude, and organizational learning in alliances, *Management Decision*, Vol. 49, No. 1, pp. 156-166.

Stank, T.P., Davis, B.R. and Fugate, B.S. (2005) A strategic framework for supply chain orientated logistics, *Journal of Business Logistics*, Vol. 26, No. 2, pp. 27-45.

Starkey, K., Tempest, S. and McKinlay, A. (2004) *How Organizations Learn – Managing the search for Knowledge*, 2nd ed, Thomson Learning, London, UK.

Stern, N. (2007) *The Economics of Climate Change: The Stern Review*, Cambridge University Press, Cambridge, United Kingdom.

Stock, J.R. and Boyer, S.L. (2009) Developing a consensus definition of supply chain management: aqualitative study, *International Journal of Physical Distribution & Logistics Management,* Vol. 39, No. 8, pp. 690-711.

Stonehouse, G.H. and Pemberton, J.D. (1999) Learning and knowledge management in the intelligent organisation, *Participation & Empowerment: An International Journal*, Vol. 7, No. 5, pp. 131-144.

Supply Chain Council (2011), What is the supply chain? [online] (cited 18h May 2011) available from: <http://archive.supply-chain.org/cs/root/about_us/faq#Whatisthesupplychain>

Surana, A., Kumara, S., Greaves, M., Raghavan, U.N. (2005) Supply-chain networks: a complex adaptive systems perspective, *International Journal of Production Research*, Vol. 43, No. 20, pp. 4235-4265.

Svensmark, H. and Friis-Chrsitensen, E. (2007) *Reply to Lockwood and Fröhlich – The persistent role of the Sun in climate forcing*, Danish National Space Centre – Scientific Report 3/2007.

Svensson, G. (2004) Key areas, causes and contingency planning of corporate vulnerability in supply chains, *International Journal of Physical Distribution & Logistics Management*, Vol. 34, No. 9, pp. 728-748.

Svensson, G. (2002a) The theoretical foundation of supply chain management, *International Journal of Physical Distribution & Logistics Management*, Vol. 32, No. 9, pp. 734-754.

Svensson, G. (2002b) A conceptual framework of vulnerability in firm's inbound and outbound logistics flows*, International Journal of Physical Distribution & Logistics Management*, Vol. 32, No. 2, pp. 110-134.

Tang, S.T. (2006) Robust strategies for mitigating supply chain disruptions, *International Journal of Logistics: Research and Applications*, Vol. 9, No 1, pp. 33-45

Taylor, S.S., Fisher, D. and Dufresne, R.L. (2002) The aesthetics of management storytelling: a key to organizational learning, *Management Learning*, Vol. 33 No. 3, pp. 313-30.

Tchibo (2013) [online] (cited 24th April 2013) available from: http://www.tchibo.com/.

The Free Dictionary (2012) [online] (cited 3rd October 2012) available from: http://www.the freedictionary.com/adaptation.

The Royal Academy of Engineering (2011) *Infrastructure, Engineering and Climate Change Adaptation– ensuring services in an uncertain future*, London, UK.

Tilebein, M. (2006) A complex adaptive systems approach to efficiency and innovation, *Kybernetes*, Vol. 35, No. 7, pp. 1087-1099.

TRB (2008) *Potential Impacts of Climate Change on U.S. Transportation – Special Report 290*, Transportation Research Board for the National Research Council, Washington D.C, U.S.

Tsoukas, H. (1990) *The epistemological status of ideographic research in the comparative study of organisations*, Working Paper No. 189, Manchester Business School, UK.

UKCIP [online] (cited 04. April 2010) available from: <http://www.ukcip.org.uk/index.php?id=234&option=com_content&task=view#Weather>.

UNFCCC [online] (cited 24. May 2010), available from: <http://unfccc.int/ghg_data/ghg_data_unfccc/items/4146.php>.

UTZ (2013) UTZcertified, [online] (cited 26th April 2013) available from: https://www.utzcertified.org/en

Van der Put, T. (2013) *The Sustainable Coffee Program Powered by IDH*, presentation at the 10th African Fine Coffee Conference, February 16th 2013, Kampala, Uganda.

Van Hoek, R.I., Harrison, A. and Christopher, M. (2001) Measuring agile capabilities in the supply chain*, International Journal of Operations & Production Management*, Vol. 21, No. 1, pp. 126-147.

Varga, L., Allen, P.M., Strathern, M. and Rose-Anderssen, C. (2009) Sustainable Supply Networks: A Complex Systems Perspective, *E:CO*, Vol. 11, No. 3, pp. 16-36.

Veizer, J. (2005) Celestial Climate Driver: A Perspective from Four Billion Year of Carbon Cycle, *Geoscience Canada*, Vol. 32, No. 1, pp. 13-14.

Von Krogh, Ichijo, K., Nonaka, I. (2000) *Enabling Knowledge Creation: How to Unlock the Mystery of Tacit Knowledge and Release the Power of Innovation*, Oxford University Press, New York.

Voss, C., Tsikriktsis, N. And Froehlich, M. (2002) Case research in operations management, *International Journal of Operations & Production Management*, Vol. 22, No. 2, pp. 195 219.

Vrasidas, C. (2001) Interpretivism and Symbolic Interactionism: Making the Familiar Strange and Interesting Again in Educational Technology Research, in Heinecke, W. and Willis, J. (Eds) *Research Methods in Educational Technology*,CT: Information Age Publishing, Inc., Greenwich.

Wagner, S.M. and Bode, C. (2008) An empirical examination of supply chain performance along several dimensions of risk, *Journal of Business Logistics*, Vol. 29, No. 1, pp. 307-325.

Walker, G. and King, D. (2008) *The Hot Topic – What we can do about global warming*, Bloomsbury Publishing Plc., U.K.

White, D. (1995) Application of systems thinking to risk management: a review of the literature, *Management Decision*, Vol. 33, No. 10, pp. 35-45.

WMO [online] (cited 02. April 2010) available from: <http://www.wmo.int/pages/themes /climat e/understanding_climate.php>.

Woods, D (2006) 'Resilience: Essential Characteristics of Resilience', in Hollnagel, E; Woods, D., and Leveson, N. (editors), *Resilience Engineering: Concepts and Precepts*, Ashgate Publishing Company, UK, pp. 21-33

Wu, T., Blackhurst, J. and Chidambaram, V. (2006) A model for inbound supply risk analysis, *Computers in Industries*, Vol. 57, pp. 350-365.

Wulun, J. (2007) Understanding complexity, challenging traditional ways of thinking, *Systems Research and Behavioral Science*, Vol. 24, pp. 393-402.

WWF and Allianz (2009) *Major Tipping Points in the Earth's Climate System and Consequences for the Insurance Sector*, Gland, Switzerland and Munich, Germany.

Wysick, C., McKelvey, B. and Hülsmann, M. (2008)Smart parts' supply networks as complex adaptive systems: analysis and implications, *International Journal of Physical Distribution & Logistics Management*, Vol. 38, No. 2, pp. 108-125.

Yates, J.F. and Stone, E. (1992) "The risk construct" in Yates, J.F. (Ed.), *Risk-taking Behaviour*, Wiley, Chichester.

Yin, R.K. (2009) *Case Study Research – Design and Methods*, 4th edition, Sage Ltd, London, UK.

Zietsma, C., Winn, M., Branzel, O. and Vertinsky, I. (2002) The war of the words: Facilitators and impediments of organizational learning processes, *British Journal of Management*, Vol. 13, Special Issue, pp. 61-74.

Zsidisin, G. A. (2003) A grounded definition of supply risk, *Journal of Purchasing & Supply Management*, Vol. 9, No. 5, pp. 217-224.

Zsidisin, G.A., Panelli, A. and Upton, R. (2000) Purchasing organization involvement in risk assessments, contingency plans, and risk management: an exploratory study, *Supply Chain Management: An International Journal*, Vol. 5, No. 4, pp. 187-197.