Decarbonization barrier upstream in the supply chain amongst lower-tier suppliers

A case study of the IT-services sector

Master's thesis in the Master's Programme Sustainable Energy Systems

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Abstract

Global warming and climate change have emerged as one of the greatest threats for ecological balance. The increase in global carbon emissions is the main reason for climate change. To address this topic, the Intergovernmental Panel on Climate Change (IPCC) has published comprehensive reports so that organizations can get a summary about the drivers of climate change, its impacts and reduction techniques. The latest report published in April stressed on the approach towards Carbon net zero to reduce the global greenhouse gas emissions if we must limit the earth's temperature to 1.5°C. Carbon net zero is a holistic approach to reduction of carbon emission where all the actors in the supply chain are equally responsible for reducing their own carbon emissions.

The IT services and consulting sector has a major contribution to the global carbon emissions since it works in synergy with other different carbon intensive sectors to run their operations. The current ESG policies include and govern suppliers who are responsible for the scope 1 and 2 emissions. Scope 3 emissions are all indirect emissions that are a released into the atmosphere and are a part of the value chain of the company. Scope 3 emissions are significantly rising across the globe and has been a major concern threatening the climate goals and proving as a hinderance to achieve carbon net zero. Currently, the major portion of emissions in a company's supply chain occurs at lower-tier suppliers who are located upstream in the supply chain. The lower-tier suppliers often lie outside the visibility horizon and are not aware of the sustainability requirements of the organizations. Even if they do have an understanding, they are SME's and do not have the budget to take up sustainable practices. They are usually located in countries where the regulations are not strict. It is extremely important that lower-tier suppliers are aware of the sustainability requirements and their role in managing their sub-supplier sustainability is critical for supply chain decarbonization for achieving carbon net zero.

Acknowledgements

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I wish to extend my special thanks to Viswanathan Rajendran from Capgemini who was the main mentor throughout the course of the thesis study. Also, I would like to extend my thanks to Sylvia Elweskiold from Capgemini who has also provided valuable feedback during the course of this study.

Rohan Sudhindra Shandilya, November 2022

Contents

List of tables

List of figures

1.Introduction

This chapter of the report provides a background behind the thesis study, purpose & research questions, and delimitations to the project. The background section explains the reason why this thesis study is being carried out. The purpose & research questions section expresses the need for this study, the importance of this study and the details that are going to be expected from this thesis study. The delimitations section lists out the assumptions made and other material that are not a part of this thesis study but have relevance to this topic.

1.1 Background

Global warming and climate change have emerged as one of the greatest threats for ecological balance and is also being termed as the reason human survival can go to extinction. The increase in global carbon emissions is the main reason for climate change and global warming (Huisingh et al., 2015). To address this topic, the Intergovernmental Panel on Climate Change (IPCC) has published comprehensive reports so that organizations can get a summary about the drivers of climate change, its impacts and reduction techniques. The latest report published in April stressed on the approach towards Carbon net zero to reduce the global greenhouse gas emissions if we must limit the earth's temperature to 1.5°C (IPCC report, 2019). Carbon net zero is the term that has replaced carbon neutral in the recent times. It is critical to understand the importance of the term "Carbon net zero" and the difference between carbon neutral and carbon net zero.

Carbon neutral is a policy that is in place to ensure and curb the increasing carbon emissions. This reduction is achieved mainly through carbon offsets. Carbon offset examples include afforestation, investments in renewable energy, investments in sustainable fuel or cattle feed etc. The offsets are sold based on an average carbon footprint basis. The risk with carbon offsets is that it is a shortcut or an easy option where organizations can easily buy offsets based on their footprint without any reduction in their carbon footprint. This leads to a risk of zero reduction in carbon emissions. To address this risk, the concept of carbon net zero has been introduced (IPCC report, 2019).

Carbon net zero is a policy that involves actual reduction in carbon emissions. The main principle of carbon net zero is to reduce as much as possible and then buy offsets for the remaining minimal emissions. Carbon net zero can be achieved using technology and alternative green energy sources.

Since it's a holistic approach to reduction of carbon emission, all the actors in the supply chain are equally responsible for achieving carbon net zero (IPCC report, 2019).

This thesis has been carried out in Capgemini which is an IT services and consulting company. Capgemini has operations in Europe, Asia and USA. Capgemini is an IT services and consulting company headquartered in France. The company has been providing IT services for the past 52 years. Capgemini is a global leader in partnering with other companies to help companies to manage and transform their business. The company provides services related to cloud, cybersecurity, data, and artificial intelligence (AI), enterprise management and sustainability. They provide services to industries in various sectors. The company has developed a strategy for carbon net zero. The company has vowed to play a leadership role in ensuring that they implement measures for sustainability internally and also help their other clients which include suppliers, policymakers, and governments to make a sustainable progress towards carbon net zero and therefore aligning with the climate goals in accordance with the Paris Agreement. Capgemini was amongst the first companies in the IT services sector to have their carbon reduction targets validated by the Science-Based Targets Initiative (SBTi). The company has charted an ambition to be carbon net zero by 2040 and reduce its carbon emissions across scopes 1,2 and 3 by 90% (Capgemini, 2022).

With increased focus on sustainability performance of organizations in all the sectors, there is pressure on organizations to highlight the sustainability drivers throughout the supply chain. The number of Multinational corporations (MNC) demanding lower-tier suppliers that adhere to social and environmental standards has increased. MNC's do require that their lower-tier suppliers also ask for compliance from their sub-suppliers. This creates a culture of multinational corporations who hold each other accountable for the compliance of social and environmental standards (Villena and Gioia, 2020). Companies have adopted a new Environmental, Social and Governance (ESG) policy to tackle this issue of supply chain sustainability. One of the main objectives of the ESG is to ensure that all the suppliers in the supply chain will have committed to the company's ESG standards. But the main challenge is to ensure that the lower-tier suppliers located upstream in the supply chain are included in the above policy and adhere to the sustainability requirements of the organization. Multi-tier supply chains are complex and hence more difficult to decarbonize due to the lack of engagement from the lower-tier suppliers located upstream in the supply chain. Figure

1 below shows the relationship between the focal company and the lower-tier suppliers. This gives an idea of the importance of the sustainability performance of these lower-tier suppliers on the sustainability performance of the focal company.

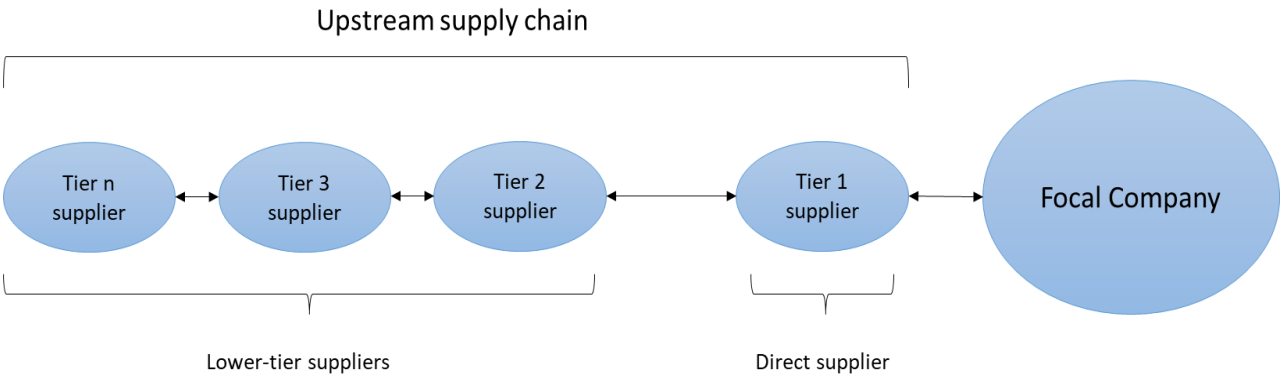

Figure 1: Relationship between focal company and upstream supply chain actors

The current ESG policies include and govern first-tier suppliers who are responsible for the scope 1 and 2 emissions. Scope 1 emissions are direct emissions from the operations of the company. It is the emissions at a firm level that are direct result of the activities of the organization. The scope 1 emissions include emissions from burnt fuel of all the vehicles owned by the firm, combustion of fuels from heating sources, fugitive emissions from air conditioning units and any emissions from on-site activities. Scope 2 emissions are the known indirect emissions released to the atmosphere from the consumption of purchased utilities (electricity, heating and cooling). Scope 3 emissions are all indirect emissions that are a released into the atmosphere and are a part of the value chain of the company (GHG protocol). Scope 3 emissions are often not tracked by the companies and as a result, scope 3 emissions are significantly rising across the globe and has been a major concern threatening the climate goals and proving as a hinderance to supply chain decarbonization. Currently, the major portion of emissions in a company's supply chain are scope 3 emissions that occur at lower-tier suppliers who are located upstream in the supply chain (Tate et al., 2016).

Capgemini has a strong ESG policy, and the policy currently is focused on accelerating the transition to net zero. The policy has two priorities. The first priority focuses on environmental issues and the main objective of this priority is to be carbon neutral in own operations no later than 2025. The priority stresses on achieving a carbon neutral supply chain by 2030. Capgemini had set

its first target in the year 2016 to reduce their carbon footprint by 30% before the year 2030 and achieved the target in 2020 itself, 10 years ahead of the schedule. After achieving the target, the company set new net zero targets with two new essential components. The first and most important target was to develop a strategy to reduce emissions in their supply chain in line with the targets set to align with the 1.5°C climate target. This strategy listed a few focus areas of concern with higher carbon emissions. The focus areas were transitioning to renewable energy, switching to electric vehicles, and increasing engagement with suppliers. The second target was to develop carbon offsetting program to offset residual emissions. The strategy to achieve this target was to focus on projects like on-site renewable energy generation and re-forestation (Capgemini, 2022)..

The second priority is to lead the transition towards a low-carbon economy by helping clients achieve environmental targets. The main objective of this priority was to help clients reduce their carbon emissions by 10m tons of CO_2 equivalent by 2030. The strategy includes helping clients measure their GHG emissions and develop strategies to help reduce these emissions. The strategy focuses both on the positive and negative impacts. The positive impact focuses on the potential for emission reduction whereas the negative impacts focus on the carbon impact associated with the implementation of the project (Capgemini, 2022).

1.2 Purpose and Research questions

Existing research has shown that companies are overshadowed by the emissions from their supply chain than direct emissions. In order to reduce supply chain emissions, firms must engage and work with their lower-tier suppliers. It is significantly important that firms with multi-tier supply chain play a leadership role by not only considering their emissions but also of their suppliers (direct and lower tier) and attempt to reduce emissions by providing valuable information and assistance. However, as discussed earlier, the major portion of emissions in a company's supply chain occurs at lower-tier suppliers who are located upstream in the supply chain. To curb these emissions, recent initiatives like the Science based target initiative (SBTi), have come up with sector specific guidelines and has resulted in pressuring organizations to highlight the sustainability drivers throughout the supply chain. The number of MNC's demanding lower-tier suppliers adhere to environmental standards has increased. A complete understanding of the company's sustainability profile requires an understanding of the complete supply chain and not only the first-tier suppliers (Meinlschmidt et al., 2017). REACH in the European Union (EU) is another

compliance standard has pressurized firms to collect sustainability-information from their lower-tier suppliers. Even though MNC's are pressurizing their suppliers to take up sustainable practices and provide sustainability related data, the focus is mainly on the first-tier suppliers. As all actors play an important role in the decarbonizing the supply chain, it is extremely important that lower-tier suppliers also implement measures towards reducing their own carbon emissions.

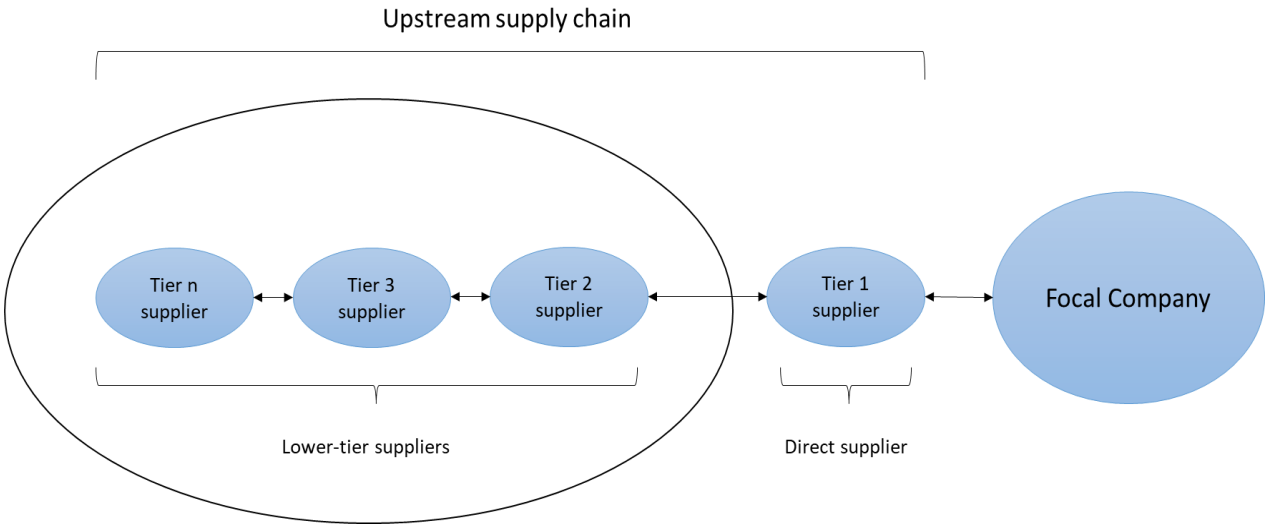

Figure 2: Representation of the boundary consideration for this thesis

Since the major portion of scope 3 emissions in a company's supply chain occurs at lower-tier suppliers who are located upstream in the supply chain, the focus of this thesis will be on the lower-tier suppliers located upstream in the supply chain as shown in Figure 2. According to the report published by the Word resources institute (WRI) in June 2022, Scope 3 emissions account for 75% of the companies GHG emissions. 80% of the scope 3 emissions occur in the upstream activities in the supply chain of the organization. Upstream activities in the supply chain include: 1) Business travel 2) Waste generated in operations in the supply chain 3) Goods and services that are purchased by companies (includes both direct and indirect material 4) Transportation and distribution in the entire supply chain 5) Energy and fuel consumption 6) Use of buildings, building equipment for heating and cooling 7) Machinery for maintenance and vehicles are all considered as capital goods. Currently, the major portion of emissions in a company's supply chain occurs at lower-tier suppliers who are located upstream in the supply chain (Tate et al., 2016). Capgemini has supported this thesis as even they are facing the difficulty to ensure that their lower-tier suppliers located upstream in their supply chain align with the sustainability requirements.

The lower-tier suppliers are often small and medium sized enterprises with less capital and are also based in different countries where the sustainability standards are low (Foerstl et. al, 2015). The lower-tier suppliers often lie outside the visibility horizon and hence they do not attract the attention from any of the stakeholders or the media. Because of the lack of attention, the lower-tier suppliers do not feel pressurized to take up sustainable practices and are usually not aware of the sustainability requirements of the organizations (Villena and Gioia, 2020). Studies have explored various industries and sectors to identify barriers for supply chain decarbonization. There are very few articles on supply chain decarbonization in the IT services and consulting sector. All the available literature is explored by consulting firms as they have commercial interest in offering solutions to their clients (Zhang et.al., 2022). The paper by Burchard et.al., (2021) which considered Boston consulting group consultants, have identified lack of awareness about sustainability amongst lower-tier suppliers and high upfront costs for low-carbon technology implementation as the main barriers for decarbonization of supply chains. They discuss that the barriers get more challenging for organizations with multi-tier supply chains. Another report by McKinsey group in 2011 identified some important barriers for decarbonization. The main barriers that they identified were lack of awareness and knowledge in lower-tier suppliers, overreliance on secondary data of scope 3 emissions, transparency and cost and technical feasibility in lower-tiers of the supply chain (Zhang et.al., 2022). There is an overall lack of research on the barriers faced by lower-tier suppliers in the supply chain of the IT services and consulting sector for implementation of sustainability and the implications of their performance on supply chain decarbonization. The lack of research on decarbonization barriers amongst lower-tier suppliers and strategy used for sustainability implementation has led to the formulation of the first set of research questions:

RQ1. What are the barriers faced by lower-tier suppliers for implementing environmental sustainability in their operations?

RQ2. What are the strategies adopted by lower-tier suppliers to ensure implementation of environmental sustainability in their operations?

Companies have multi-tier supply chains, and it is therefore very expensive and difficult to monitor the sustainability of all their lower-tier suppliers. The main challenge for organizations is to monitor the performance of their lower-tier suppliers. The lower-tier suppliers often lie outside the visibility horizon and hence they do not attract the attention from any of the stakeholders or the

media. Because of the lack of attention, the lower-tier suppliers do not feel pressurized to take up sustainable practices and are usually not aware of the sustainability requirements of the organizations. Lower-tier suppliers often do not have knowledge about sustainability. It is extremely important that lower-tier suppliers are aware of the sustainability requirements and their role in monitoring their sub-supplier sustainability performance is critical. Existing research on the strategies used by companies to monitor the sustainability performance of their suppliers focus mainly on the relationship of the focal company along with the first-tier suppliers. The monitoring of the lower-tier suppliers is mostly vested upon the first-tier suppliers. But there is lack of research to understand the strategies used by lower-tier suppliers to monitor their sub-supplier sustainability performance. The lack of research on the strategies used by lower-tier suppliers to monitor the sustainability performance of their sub-suppliers has led to the following research question:

RQ3. What are the strategies used by lower-tier suppliers to monitor their sub-supplier sustainability performance?

The purpose of this thesis study is to identify the barriers faced by lower-tier suppliers located upstream in the supply chain to implement environmental sustainability practices in their operations. The thesis will identify the strategies implemented by lower-tier suppliers to achieve environmental sustainability. Lastly, this thesis will investigate the strategies used by lower-tier suppliers to monitor the environmental sustainability performance of their sub-suppliers. This thesis study will help answer the following research questions:

1.3 Delimitations

The thesis study is based on currently available literature. The study will explore materials and processes that are transparently available, and it might not identify all of them. The processes or materials identified have no alternatives as of the time of this study. Alternative materials or processes might arise in the future. The developed framework is only based on the environmental aspect of sustainability and does not consider the social aspect. The study assumes that there is already an efficient management system in place for the first-tier suppliers of direct material and does not include any study with respect to the relationship and management between the focal company and the first-tier suppliers and does not involve any discussion or study for direct material. Any framework suggested is just a proposal, and this thesis study will not include any comments or feasibility of the implementation of this proposed framework.

1.4 Thesis Structure

The thesis will be structured into 5 chapters. Chapter 2 will present the theory behind lower-tier supplier management (LTSM) and the barriers for implementation of sustainable supply chain management (SSCM) in LTSM. Chapter 3 will present the method followed for the thesis. The data from the interviews and supplier questionnaire will be presented in Chapter 4. The research questions and suggestions based on the results will be presented in Chapter 5. Lastly, Chapter 6 will provide an overview with a conclusion and scope for further research.

1. Introduction
2. Theoretical background
3. Methodology
4. Empirical data
5. Discussion
6. Conclusion

2. Theoretical background

This chapter provides an overview of the existing literature. It includes sustainable supply chain management (SSCM), managing sustainability in multi-tier supply chains, decarbonization in lower tiers of the supply chain, global environmental standards for sustainability and scope 3 emissions.

2.1 Sustainable supply chain management (SSCM)

Supply chain management (SCM) is a holistic approach and concerns a wider system such as a network and is not only restricted to the firm's supply chain. Supply chain management usually deals with divergent and convergent flows and is usually a complex network. Such networks include competitive relations between suppliers and customer and involves many other intermediate actors (Erridge and Mcllroy, 2002). The main challenge in such a complicated network is to create a win-win situation for all the involved actors in the supply chain.

Sustainable supply chain management (SSCM) is described as the management strategy used by an organization to manage the issues in a supply chain. The SSCM definition is developed according to the triple bottom line – environmental, economic and social issues (Odeh and Smallwood, 2012).

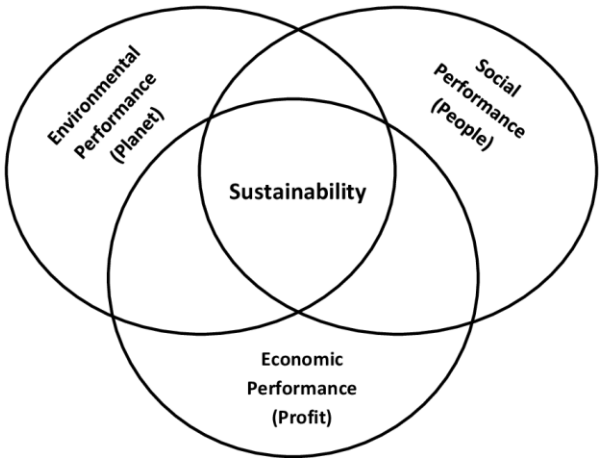

Figure 3:Triple bottom line framework for SSCM (Carter and Rogers, 2008)

This definition of SSCM integrates issues in both upstream and downstream supply chain partners. This definition emphasizes that sustainability can be achieved by a firm only if sustainability is extended to all the suppliers involved in the supply chain (Sancha et al., 2019). Most of the medium

scale and big organizations have complicated multi-tier supply chains with suppliers located in different countries. This global spread of suppliers leads to sustainability risks as the suppliers are in countries where the environmental sustainability standards are low (Foerstl et. al, 2015). Organizations have adopted supplier development practices that have helped suppliers to improve their sustainability performance. This supplier development practice involves supplier assessment and governance. A lot of papers have studied about supplier collaboration and assessments from an environmental perspective, but the focus of these papers is on the first-tier suppliers (Sancha et al., 2019). Organizations interact directly with their first-tier suppliers and conduct assessments. Since most of the environmental impact is caused upstream in the supply chain, it is critically important to study this gap to enable companies to understand the importance of extending sustainability to the lower tiers in the supply chain (Willhelm et al., 2016).

2.2 Managing sustainability in multi-tier supply chains

In a paper on managing sustainability in multi-tier supply chains, the authors have proposed four different approaches – direct, indirect, third-party collaboration and don't bother (Tachizawa et.al, 2014). The paper puts forward certain factors which will help the organization to consider the right approach. In the direct approach, the focal company has direct access to lower-tier suppliers and hence the company can easily interact with the lower-tier suppliers and to govern and monitor their environmental sustainability performance. In the indirect approach, the lower-tier suppliers will be directly monitored by the first-tier suppliers. The focal company will allocate the responsibility of governance and monitoring of the lower-tier suppliers to the first-tier supplier. In the Third-party approach, the focal company will collaborate with an NGO or another centralized firm which manages the monitoring of suppliers for firms in the same industry and these firms might also use third-party databases to monitor the sustainability of the suppliers. The Don't bother approach is where firms focus only on the first-tier suppliers and have less intention to influence them to adhere to or follow sustainability standards (Tachizawa et.al, 2014).

Most of the existing literature in this stream focuses on the immediate sub-supplier management strategies and neglect the lower-tier suppliers. Grimm et al. (2014) is a classic example of such a study of immediate sub-supplier sustainability performance. Several papers like Grimm et al., (2016); Mena et al., (2013); Villena and Gioia, (2018) have also only looked into the collaboration of companies with their first-tier suppliers and their immediate sub-suppliers (Sancha et al., 2018).

Grimm et al. (2016) mention that recent surveys reveal that only 10-15% of corporations require their sub-suppliers to comply with sustainability standards. They also mention that most of the monitoring of the sub-suppliers is assigned to the first-tier suppliers (Grimm et al., 2014). These papers have provided a platform for further research to be carried out concerning the lower-tier suppliers. But as the supply chain grows in tiers, there is a challenge in monitoring their sustainability performance. The above studies have investigated supplier management strategies of suppliers that are in the visible horizon of the organization. But the main challenge is the management of lower-tier suppliers that are beyond the visibility horizon of the organization (Sancha et al., 2018).

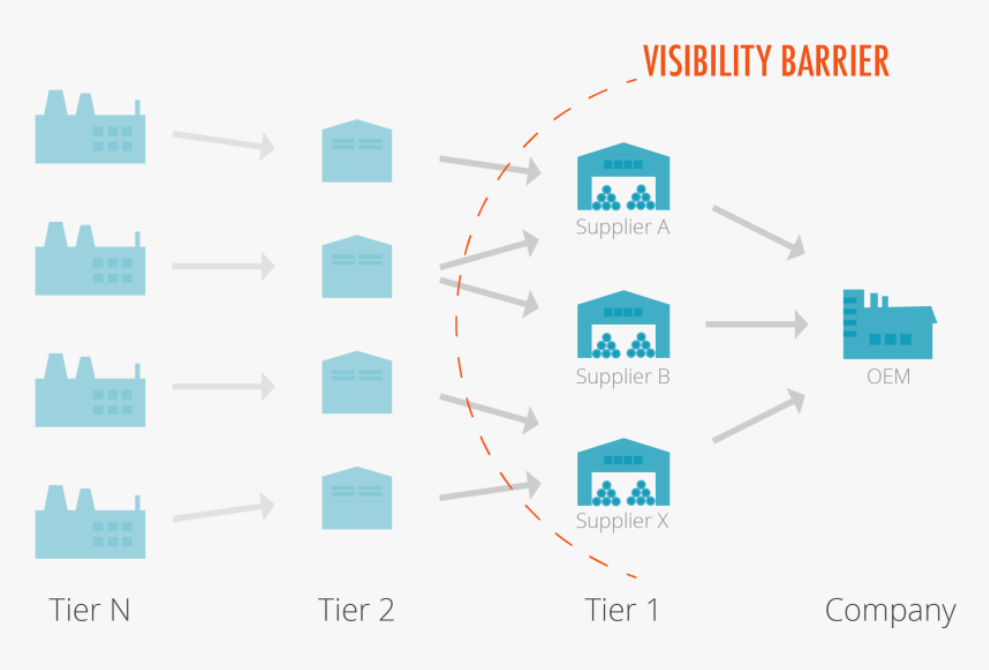

Figure 4: A schematic representation of a multi-tier supply chain and visibility barrier

The pressure on organizations to highlight sustainability drivers throughout the supply chain has been intensified in the latest sustainability approaches. The main challenge for organizations is to monitor the performance of their lower-tier suppliers. The lower-tier suppliers often lie outside the visibility horizon and hence they do not attract the attention from any of the stakeholders or the media. Because of the lack of attention, the lower-tier suppliers do not feel pressurized to take up sustainable practices and are usually not aware of the sustainability requirements of the organizations. Lower-tier suppliers often do not have knowledge about sustainability (Villena and Gioia, 2020).

2.3 Decarbonization in lower tiers of the supply chain

SSCM implementation for decarbonization is incredibly challenging as the tiers keep growing in the supply chain of an organization. As discussed in the previous section on LTSM, one of the main challenges is to communicate and ensure that the lower-tier suppliers understand sustainability requirements of the organization and to also ensure that these suppliers are monitoring their sub-supplier performance further upstream in the supply chain (Villena and Gioia, 2020). Like firms and first-tier suppliers, lower-tier suppliers also face barriers to implement sustainability internally and externally. Internal barriers include understanding the new concept of sustainability, high investment costs for sustainability integration and lack of data for measuring their own sustainability performance. External barriers are resistance from sub-suppliers and lack of knowledge of regulations in a different country (Rauer and Kaufmann, 2015).

2.3.1 Barriers for sustainability implementation

This section provides information that is explored in the existing literature with respect to the barriers for implementation of sustainability measures amongst lower-tier suppliers. As discussed in brief in the earlier sections, the main barriers for decarbonization in the upstream supply chain amongst lower-tier suppliers is the lack of awareness which is categorized as an external barrier. Since these suppliers are located further upstream in the supply chain, they are not aware of the sustainability requirements. Since lower-tier suppliers are SMEs located in a different country, cost is another key internal barrier for implementation of sustainability (Sajjad et al., 2015).

2.3.1.1 Internal barriers

Odeh and Smallwood also discuss that one of the main barriers for implementation of SSCM in lower-tier suppliers is the high *cost* of developing environmental management systems to enforce and monitor sustainability performance. They also provide examples of other papers like Min & Galle , Hines & Johns and Farahani, Asgari, & Davarzani that have explored the same result of high cost being the main barrier for implementation of SSCM amongst lower-tier suppliers in the supply chain network (Odeh and Smallwood, 2012). Schmidt and Osebold (2014) explore various barrier for implementation of EMS in companies. They identify that increase in managemental and operational costs is one of the main barriers for implementation of EMS. They find that suppliers mention that the permits and certificates are expensive. They provide examples of ISO 14001

certifications that are very expensive. The paper also discusses that suppliers mention that implementation of EMS will result in a significant increase in operational costs. The strategies for EMS implementation require change in operational strategy and also new investments in technology. The paper Granoff et.al, (2016) list the various barriers that affect an organization to invest in low carbon infrastructure. They identify that the main barriers are *Cost, and lack of awareness*. Shao Hung Goh in his paper on the barriers for low carbon investments ranks different countries in Asia (which holds the biggest supplier base for material production) and concludes that *cost* is the main barriers for low carbon investments. Uneconomical recycling methods and uneconomical re-use structures in place have also influenced developing SSCM strategies for lower tier suppliers (Rauer and Kaufmann, 2015). Like the literature described above, suppliers respond that the investment cost for environmentally sustainable systems was high. They mentioned that the high cost resulted in non-implementation of environmental sustainability (Ramirez et. al., 2013). The current technologies for decarbonization have high upfront costs. The technologies for low emission are not completely developed. There are ongoing developments and research to identify more low carbon emission technologies. The technologies available as of today are not completely commercialized. Lack of new technology to reduce waste and increase efficiency has also developed as a barrier for decarbonization. Due to these factors, these technologies are way more expensive than the existing technologies which do not promote reduction in emissions. These high investment costs prove to be a barrier for SMEs to uptake low-carbon technologies. Also, due to the development of technologies mostly in developed countries, SMEs located in developing countries have difficulty to get an understanding of the concept. This is also accompanied with trade and higher costs for access to information and the technology. Another problem is the loss incurred during integration of low carbon technologies (Oberthur et.al., 2020). SMEs have less resources and incurring costs for implementation of sustainability makes the cost more significant and also makes the SME more vulnerable. Often, the implementation of sustainability in SMEs have a negative impact on their sub-suppliers. The local small suppliers lack the required capital to make new investments to meet the sustainability requirements. The investment needed for management of implemented measures also require capital and hence integration of sustainability proves to become a burden on lower-tier suppliers by contributing to increase in operational costs (Walker et.al., 2008). In a paper on barriers for circular supply chains in the textile industry, the authors discuss various barriers for implementation of circular measures

in the supply chain. Since the consulting sector procures a lot of furniture made from fabric, these insights are important. The paper discusses that lower-tier suppliers face high investment cost as the main barrier. Implementation of new technology is expensive. The cost of recycling is high, and the procurement of recycled material is more compared to processing virgin raw materials. The cost incurred for training the employees increases the investment cost. The suppliers mention that they feel the burden as the customer is not willing to pay additional cost for the low carbon product. Since the demand for a low carbon product is low, the volume of production is less, and this results in higher production cost. Since the concept is still new, suppliers are uncertain about the time of return on investments. The collection cost for material to be recycled is an added operational cost. This cost will vary depending on the volume and this proves to be expensive for lower-tier suppliers (Kazancoglu et.al., 2020).

2.3.1.2 External barriers

Rauer and Kaufmann in their paper on Barriers to Green SCM focusing on rare earth metals have collected data from manufacturers regarding barriers faced by their green-tech component suppliers. They have categorized the findings based on two categories: Supply chain structure related barriers originating from a lack of transparency in the supply chain and Environmental standards-related barriers which originate due to lack of conceptual knowledge of environmental regulations and enforcement of environmental standards. Supply chain structure related barriers comprise of lack of supply chain transparency and lack of influence on sub-suppliers. We have already discussed in the LTSM section about the difficulty and barriers faced in multi-tier supply chains. The findings revealed that most of the suppliers had environmental standards as a part of their supplier code of conducts. However, no efforts were made to monitor the adherence of sub-suppliers. Their study also reveals that since suppliers struggle to take up sustainable practices themselves, they cannot influence their sub-suppliers on the environmental standards (Rauer and Kaufmann, 2015). Environmental standards-related barriers arise due to the absence of understanding of a generalized sustainability target like carbon dioxide emission standard. This paper exposes the gap in the understanding of environmental impact caused by the supplier. This is due to the fact of different environmental regulations in different countries. Due to a global spread of supplier network, it is usually difficult for lower-tier suppliers to align with the sustainability targets of the companies that are based in developed countries and have strict

regulations unlike the liberal regulations that are prevailing in the country of location of lower-tier supplier where the enforcement is less strict, and the regulations are not as demanding (Rauer and Kaufmann, 2015). In a paper on barriers for EMS implementation, the main barriers identified are lack of knowledge about the sustainability standards such as ISO, waste management standards, lack of expertise and lack of governmental pressure. The paper discusses these barriers in detail. The discussion mentions that suppliers often have no knowledge about the sustainability standards and requirements. SMEs are located in developing countries and hence lack access to knowledge about these requirements. The suppliers participating in the study mention that even if companies help them overcome the knowledge barrier, they lack resources to implement the strategies. There is shortage of trained professionals to implement the strategies. They mention that they meet the sustainability requirements of the country that they are located and hence do not feel pressurized to implement additional measures (Schmidt and Osebold, 2014).

It is challenging for the lower-tier suppliers to translate the strategies into activities because of the lack of knowledge and understanding about sustainability. It is difficult to interpret the sustainability requirements of focal company as there is a lack of understanding about the requirements. Even if a senior professional understands the requirements, it requires an effort from a large group of people working in the organization for implementation (Abbasi & Nilsson, 2012). The literacy rate of sustainability practices and requirements is very low amongst lower-tier suppliers. There is a lack of engagement from the top-level management in the focal company. The lower-tier suppliers are not bothered or pressurized and hence they do not feel motivated to gain knowledge and understand the requirements. There is a lack of guidance regarding environmental standards. The suppliers are not aware of the indicators and there is a lack of clarity between the different tiers in the supply chain. Another barrier is the lack of performance metrics to measure sustainability. Due to the lack of measuring sustainability, the suppliers are not in a position amongst their sub-suppliers. The evaluation methods for sustainability performance are not uniform and there is lack of standards for quantifying the data (Menon and Ravi, 2021). In a paper on corporate supply chain responsibility: Drivers and Barriers, the authors identify that there is lack of knowledge amongst lower-tier suppliers about the sustainability strategies. There is also lack of guidance on how these requirements should be prioritized and implemented. They identify that sustainability strategies are complicated to decipher. They discuss various quotes from the suppliers they interviewed that sustainability criteria are often difficult to understand (Chkanikova

and Mont, 2012). SMEs are usually located in countries with less strict environmental regulations. The sustainability requirements of the focal company in a different country usually proves to be difficult to interpret. Suppliers do not understand how the implementation of sustainability should be carried out as there is a lack of understanding of environmental management, laws, evaluation methods, sustainability requirements and available technologies. The lack of communication between the focal company, first-tier suppliers and lower-tier suppliers results in the lower-tier suppliers not being aware of the updated regulations. The lower-tier suppliers were not fully aware of the environmental regulations and the sustainability requirements (Herren and Hadley, 2010).

In a paper on deep decarbonization of energy intensive industries, the authors discuss about the main barriers for the decarbonization of the steel, chemicals, aluminum, and cement industry. These industries are responsible for the majority of the material that is used in the final product used by IT services companies. These industries are extremely energy intensive and hence contribute greatly to the global GHG emissions. Their operations also result in industrial wastewater as a byproduct of the process. One of the main barriers discussed is the lack of knowledge and this is due to lack of standardized frameworks. The product standards, sustainability requirements and labelling measures are different in different countries. Lower-tier suppliers located in a different country with less strict regulations are not motivated to meet the standards of the focal company as they have already fulfilled the requirements of the country in which they are located. The lower-tier suppliers are unaware of the sustainability requirements and labelling measures. The authors discuss how the recycling requirements are not met by lower-tier suppliers as they lack knowledge about the requirements and also the resources and technologies for implementation. They further discuss that even if the requirements are conveyed to the lower-tier suppliers, the global supply chains are often complex, and the varying requirements cause confusion and difficulty for implementation. Another important barrier that is discussed in the paper is the lack of understanding of the action plan of the strategy. Some companies do engage with the lower-tier suppliers and make them aware of the requirements. But the lower-tier suppliers lack the knowledge and maturity of the working and implementation of the technology. This is one of the main barriers for low-carbon technology implementation (Oberthur et.al., 2020). The main barriers for decarbonization in SMEs are due to the lack of awareness and lack of support from supply chain partners. A paper on barriers for decarbonization discusses that lack of awareness is a significant barrier. The paper finds that suppliers from all the three countries considered in the

study mentioned that they were not aware of the sustainability requirements of the focal company which was in a different country. They discuss that suppliers who have overseas customers are sometimes made aware of the requirements depending on the product they supply. However, the suppliers mention that their local sub-suppliers are not aware of the emission-related concerns and the suppliers were not motivated to understand the concept due to the lack of awareness of how they would benefit from such a measure (Zhang et.al., 2022).

2.3.2 Strategies for sustainability implementation

The SBTi has listed the main strategies to tackle the scope 3 emissions and decarbonize the IT sector to align with the 1.5°C trajectory. These strategies include immediate action in *Implementation of energy efficiency plans and switching to renewable/low carbon electricity supply*. There are many papers on sustainability implementation for achieving carbon emission reduction. This section provides an insight about the existing strategies and technologies for carbon emission reduction and implementation of sustainability measures. The IT services and consulting sector procures many buildings for their operations. Large amounts of energy are required to run these buildings. The services provided also require huge amounts of energy during the manufacturing and transportation stages. Hence, the major share of material procurement in the IT services sector are buildings and energy. Achieving carbon reduction in the supply chain and operations would be possible by focusing on these two domains of material as they contribute to majority of the emissions.

Decreasing the energy consumption by improving energy efficiency is one of the strategies that has proved to be most effective in carbon emission reduction. Many papers have explored companies that have achieved energy efficiency improvement by reducing the energy consumed for lighting, heating, ventilation, and air conditioning. In a paper on energy efficiency strategies, the authors have identified that 40-50% of consistent energy use in buildings are from lighting appliances. They have discussed in their paper that improving energy efficiency by switching to LED lighting can save as much as 50% of the energy used for lighting. The authors also identify the key role of heating systems and controls and also sensors that help limit the amount of atmospheric air entering the buildings and improve the insulation of the buildings. The authors identify that more that 60% of energy savings can be achieved by installing efficient heating

systems and control mechanisms that help in better insulation of the workplace (Fedrezzi and Rogers, 2002). In a paper on building energy efficiency strategies, switching to energy efficient LED lighting with automated timer for switching on and off has proved to be a very effective strategy. Along with the LED lights, automation of the temperature controls using real time sensors in strategic points in a building has proved to help achieve 50% energy savings (Christina et.al., 2015). Papers like O'Keeffe et. al (2016) and Kolokotroni et.al., (2018) have all discussed and summarized that utilization of LED lighting, improved insulation by using automated HVAC solutions and implementation of smart sensors that help control the ambient lighting and temperature indoors results in achieving high energy savings leading to improved energy efficiency.

Renewable energy is another critical factor contributing to carbon emission reduction along with achieving energy efficiency. Many papers have identified and examined the positive impact renewable energy has had to suppliers and their carbon neutrality targets. A paper by Juan et.al., (2021) has studied that in a 20-year period between 1980 and 2018, "increase in 1% globalization has resulted in 0.0342% increase in carbon emissions whereas an increase in one unit consumption of renewable energy has reduced carbon emissions by 0.0143%". Papers like Murshed et.al., (2021); Liu et.al., (2022) and Millot & Maizi, (2021) have all discussed that transitioning to renewable energy sources has resulted in organizations and even countries achieving considerable amount of reduction in carbon emissions. Millot and Maizi, (2021) point out a very critical finding that transitioning to renewable energy has not only resulted in carbon dioxide emission reduction but has also resulted in the reduction of other toxic and harmful GHG's like nitrogen dioxide and methane. Schwalbach (2016) discusses that the reason for renewable energy becoming a popular and effective strategy for carbon neutrality is that renewable energy is environmentally friendly, results in carbon emission reduction and the main reason for companies exploring and implementing this strategy is due to the fact that it is also proving to be profitable for businesses. The paper also discusses the various incentives that businesses receive when they invest to transition to renewable energy sources. Dincer (2000) mentions that the infinite availability of renewable energy sources ensure that the companies have an indefinite source of sustainable energy supply. This helps in reducing the overall long term operating costs and they costs can also be forecasted. The SMEs also have access and availability as renewable energy is not decentralized and various sources of renewable energy is potentially available for small establishments even

located in remote areas and the flexibility to be detached and not reliant on the grid makes it more sustainable. He et.al., (2021); Khan et.al., (2021); Song et.al., (2021) and Wu et.al., (2021) have all identified different sources of renewable energy sources to substitute for the fossil fuel energy sources. All the papers have identified that majority of the energy demands in the respective domains can be met by renewable energy sources and the transition to renewable energy sources will result in a 37% decrease in carbon emissions collectively from India and China which are the major developing countries which are facing rapid industrialization. Overall, the impacts of transitioning to renewable energy have been vastly studied by various authors in different domains and based on these findings it can be taken into consideration that transitioning to renewable energy sources is one of the most important strategies to achieve carbon neutrality.

Linked to renewable energy is the electrification of the transportation sector. The transportation sector is coupled to the energy sector and thus has the potential to have a huge impact on the carbon emission reduction. Electrification of the entire transportation network in the European Union can be achieved using existing technologies and this electrification will result in 43.3% reduction in emissions linked to transport (Zhang et.al., 2022). Although a lot of papers have brought forward the challenges related to infrastructure for complete electrification, papers like Wu et.al., (2021) and Prussi et.al., (2019) has discussed that electrification of transport will help reduce the carbon emissions and accelerate the transition towards carbon neutrality. There are papers on usage of alternate fuels, but electricity has proven to be the most practical alternative. Electricity can be produced by renewable energy sources, and this will result in deep decarbonization of the transport sector (Zhang et.al., 2022).

Reducing the use of resources and waste generation are two activities that are coupled. Efficiency and reduction can be achieved by eliminating majority of the waste disposal. Waste disposal techniques and strategies demand huge amounts of energy. These are directly linked to the material used for manufacturing and the packaging material used. Associated with the materials is also the energy used for the manufacturing process and also for the disposal of the product material and also the packaging (Nizetic et.al., 2019). The paper on technologies for energy efficiency and waste management discusses that a reusable design, usage of materials that can be recovered to some extent at their EOL and also usage of environmentally friendly packaging material will help reduce up to 45% of the emissions in a supply chain. The paper on integrated approach to energy

efficiency and waste management by Vertakova et.al., (2019) reveals that recycling of materials and energy and also smart waste management techniques can help reduce the emissions related to waste by almost 40% in the supply chain.

2.3.3 Barriers for monitoring sub-supplier sustainability performance

Lower-tier suppliers often do not understand a generalized sustainability target like carbon dioxide emission standard. This is due to the fact of different environmental regulations in different countries. Due to a global spread of supplier network, it is usually difficult for lower-tier suppliers to align with the sustainability targets of the companies that are based in developed countries and have strict regulations unlike the liberal regulations that are prevailing in the country of location of lower-tier supplier where the enforcement is less strict, and the regulations are not as demanding (Rauer and Kaufmann, 2015). In a paper on barriers for supplier sustainability performance assessments, the main barriers identified are lack of knowledge about the sustainability standards, lack of expertise and lack of governmental pressure. The paper discusses these barriers in detail. The discussion mentions that suppliers often have no knowledge about the sustainability standards and requirements. SMEs are located higher upstream in the supply chain and hence lack access to knowledge about these requirements. The suppliers participating in the study mention that even if companies help them overcome the knowledge barrier, they lack resources to implement the strategies. There is shortage of trained professionals to implement the strategies. They mention that they meet the sustainability requirements of the country that they are located and hence do not feel pressurized to implement additional measures (Schmidt and Osebold, 2017).

2.3.4 Strategies for monitoring sub-supplier sustainability performance

There are a few papers that discuss strategies for sub-supplier management in multi-tier supply chains. The focus has been mainly on the strategies used by the focal company and the assessment techniques used by them. Grimm et.al., (2014) have discussed about methods such as certifications and audits used to assess the performance of the sub-suppliers. However, recent papers like Wilhelm et.al., (2016) and Tachizawa & Wong (2014) have focused more on the strategies used for managing sub-suppliers. Tachizawa & Wong (2014) have formulated four most commonly adopted strategies to monitor sub-supplier performance. These are direct, indirect, using third parties and don’t bother.

2.3.4.1 Direct

Direct strategy involves a direct contact and communication between the focal company or business and the sub-supplier irrespective of the position of the sub-supplier in the supply chain. Figure 5 is a pictorial representation of the direct strategy. The direct strategy involves giving ad hoc suggestions. This strategy involves the business or focal company directly involved in conducting on-site trainings and audits. This strategy helps the business or company build a strong relationship also increases the control of the focal company over the sub-suppliers. Firms usually use the direct approach when the sub-supplier is a supplier of critical and sensitive material or services subject to high risk in terms of sustainability (Tachizawa and Wong, 2014). The main challenge with this approach is the lack of resources such as time capital and knowledge. The lower-tier suppliers are based in different countries and hence a lot of capital is required for monitoring these lower-tier suppliers. The suppliers do not reveal the depth of their respective supply chain which creates a gap of knowledge. There is also lack of information from sub-suppliers located in developing countries as they often do not disclose all the required information (Lee, 2010).

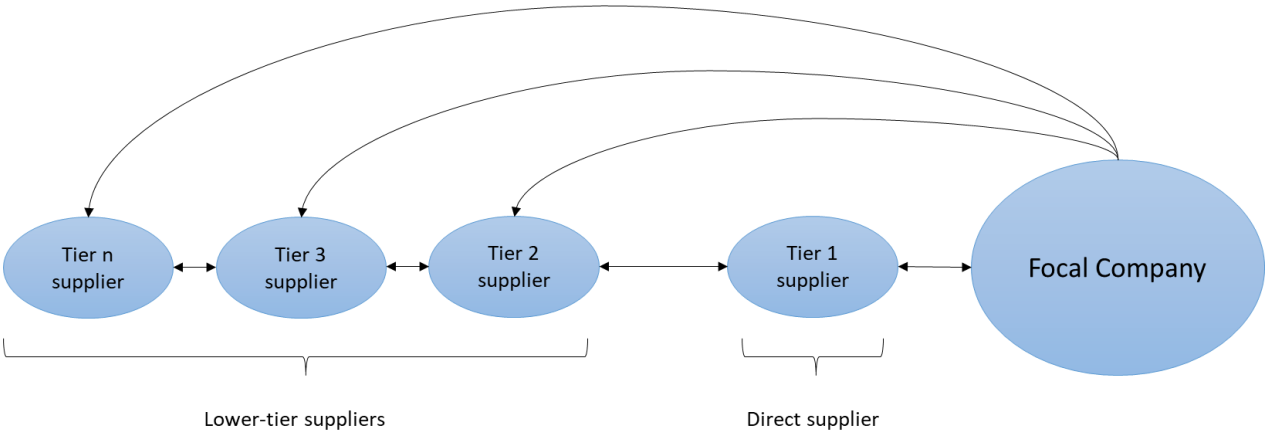

Figure 5: Sub-supplier management using direct strategy

2.3.4.2 Indirect

Indirect strategy is a strategy where the focal company or business does not have direct contact with the sub-supplier. The sub-supplier performance monitoring is vested upon the direct supplier or tier 1 supplier as shown in Figure 6. The code of conduct and sustainability requirements are

enforced upon the tier 1 suppliers by the focal company or business, and these have to be delegated to the lower-tier suppliers further upstream in the supply chain. This approach creates a culture of cross-tier collaboration in the supply chain. This involves all actors in the supply chain and all the suppliers are aware of the performance of other suppliers either higher or lower in the supply chain as there is interdependency for information. Tier 1 suppliers are dependent on the Tier 2 suppliers to get information about their own performance and also the performance of their sub-supplier – Tier 3. The focal company or business provides the requirements and training to the first-tier supplier and certifications are used to indirectly manage sub-supplier performance by ensuring the first-tier suppliers demand the required certificates from the sub-suppliers (Tachizawa and Wong, 2014). The main challenge with this approach is that direct suppliers are independent actors and therefore they might manipulate the performance assessments of the sub-suppliers in order to maintain their reputation and relationship with the focal company. This will lead to a probability where the first-tier suppliers withhold certain information as it might cause a conflict with the focal company's requirements (Wilhelm et al. 2016).

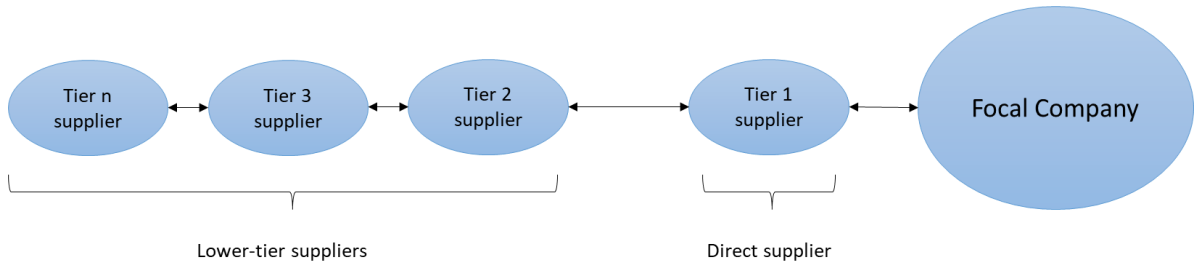

Figure 6: Sub-supplier management using indirect strategy

2.3.4.3 Third parties

This approach as the name suggests involves a third party to assist in the sub-supplier performance management. Third parties include NGO's, private organizations specialized in auditing or auditing firms. The sub-supplier performance monitoring and training is completely delegated to these third parties by the focal company or business. The focal company clearly communicates the sustainability requirements to the third party and the adherence to these requirements is delegated to the third party. The third party communicates and engages with the lower-tier suppliers and presents the performance assessments to the focal company or business as seen in Figure 7 (Tachizawa and Wong, 2014). The main challenge with this approach is the focal firm loses control

over the sub-suppliers. This approach would require the focal firm to constantly engage with the third party and keep them well informed about any updated requirements.

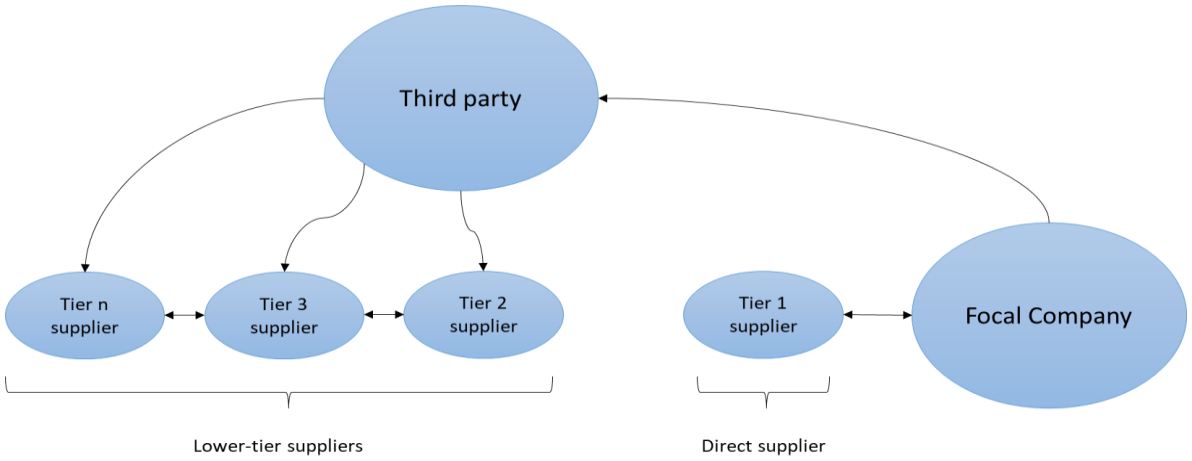

Figure 7: Sub-supplier management using third party strategy

2.3.4.4 Don't bother

This approach by a focal company or business involves focus only on the sustainability of the focal company and their first-tier suppliers. This approach eliminates the involvement of suppliers beyond the first tier. In this approach, the lower-tier suppliers are involved in any sustainability communication. This approach however is not a strategy for managing sub-suppliers (Tachizawa and Wong, 2014).

2.4 Global environmental standards for sustainability

2.4.1 Science Based Targets initiative (SBTi)

The SBTi is a partnership between CDP, the United Nations Global Compact, World Resources Institute (WRI) and the Worldwide Fund for Nature (WWF). The SBTi targets are set based on climate change studies. The targets show the companies "how much and how quickly they need to reduce their greenhouse gas (GHG) emissions." Science-based targets help companies understand the extent and timeframe of GHG reduction to prevent climate change in accordance with the Paris climate agreement to limit the earth's surface temperature to less than 1.5°C warming. SBTi is based on the concept of carbon net zero. It defines and promotes best possible ways to reduce emissions and set up net zero targets. SBTi also provides financial assistance and resources to

companies willing to set targets and provides independent assessment and validation of targets. The SBTi has developed a sector wise guidance and standards. In the Information, Technology and Services sector guidance, the SBTi have identified a sector that can meet the speeding demands through investments in renewable energy technologies. The guidance strategy published has directed the IT and services companies to reduce its supply chain scope 3 emissions by 40% by the year 2030. The main strategies to tackle the scope 3 emissions and decarbonize the ICT sector to align with the 1.5°C trajectory includes immediate action in 1. *Implementation of energy efficiency plans;* 2. *Switching to renewable/low carbon electricity supply*; 3. *Increasing carbon consciousness among end-users.* SBTi helps companies set targets. The target values are calculated yearly till the year 2030 after which new targets will be set based on the global emissions (SBTi, 2021).

2.4.2 Greenhouse Gas (GHG) Protocol

GHG protocol is a standardized global framework to measure and manage GHG emissions. GHG protocol is a detailed framework for companies to measure their GHG emissions. Like SBTi, GHG protocol is also a collaboration with WRI and the World Business Council for Sustainable Development (WBCSD). GHG protocol also offers courses for companies and helps in developing tools to help companies monitor their GHG emissions. GHG protocol standard classifies a company's emission into three scopes – Scope 1, Scope 2 and Scope 3 emissions. Scope 1 emissions are direct emissions from the operations of the company. It is the emissions at a firm level that are direct result of the activities of the organization. The scope 1 emissions include emissions from burnt fuel of all the vehicles owned by the firm, combustion of fuels from heating sources, fugitive emissions from air conditioning units and any emissions from on-site activities. Scope 2 emissions are the known indirect emissions released to the atmosphere from the consumption of purchased utilities (electricity, heating and cooling). Scope 3 emissions are all indirect emissions that are a released into the atmosphere and are a part of the value chain of the company. Scope 3 emissions are the emissions linked to the company's operations and it includes all the upstream and downstream emissions (GHG protocol, 2004).

2.5 Scope 3 emissions

Scope 3 emissions are the upstream and downstream emissions and are linked to the company's operations. Upstream activities include *Business travel* which is one of the significant contributors to scope 3 emissions that are not reported by companies. *Waste generated in operations* in the supply chain have a major contribution as waste from operations of lower tier suppliers are sent to landfills. Wastewater treatments also result in emissions. Waste disposal emits GHG's methane and nitrous oxide which are more potent than CO_2. *Goods and services* that are purchased by companies (includes both direct and indirect material) contribute to a large share of scope 3 emissions as there are emissions in the production phase. Emissions resulting from *transportation and distribution* in the entire supply chain is another contributor to scope 3 emissions. *Energy and fuel consumption* that can be termed as utilities are consumed at most of the levels in a supply chain. Emissions from consumption of these utilities during any phase in the supply chain and not included in scope1 and scope 2 will be considered as a scope 3 emission. *Capital goods* are used by the company either to manufacture a product or provide a service. Use of buildings, building equipment for heating and cooling, machinery for maintenance and vehicles are all considered as capital goods and the emissions of these capital goods from cradle-to-gate contributes to scope 3 emissions of a company (GHG protocol, 2004). The emissions from the use phase of a product or a service provided by the company should be considered for the entire timeframe that the product has been in use. *End-of-life treatment* is extremely critical to assess as much of the scope 3 emissions are from the end-of-life phase. There has been increased pressure on the suppliers or manufacturers to have an EOL policy for a product. An example of such a regulation is the Extended Producer Responsibility (EPR) that is being implemented in the European Union (Ciceri et.al, 2010). The EPR extends to even the packaging of products and is directing organizations to use recycled and more environmentally friendly packaging materials. This has resulted in a lot of importance on sustainable designs of a product or a service. But most of these practices are being implemented in the manufacturing and the use phase and have neglected the end-of-life (EOL) phase which has resulted in 64.7% of the worldwide GHG emissions from the waste generated by energy-related and industrial processes studied in one single year (Ciceri et.al, 2010). Landfilling and incineration accounts for majority of these GHG emissions during the end phase. Such waste management strategies also result in the complete loss of raw material. *Packaging* used by suppliers in the various tiers in the supply chain significantly contribute to the scope 3 emissions

based on the material used and the disposal strategy it requires. Emissions from the waste generated after use and the treatment of this waste is considered as scope 3 emissions (GHG protocol, 2004).

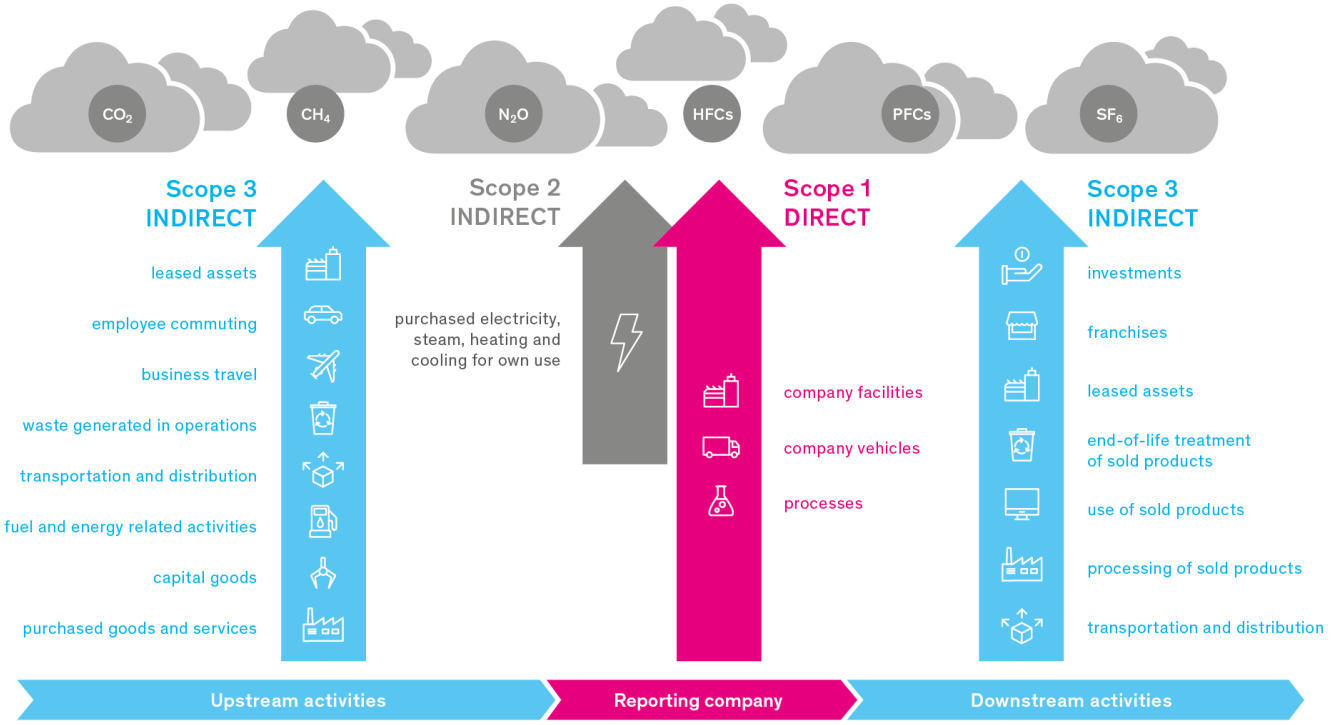

Figure 8: Overview of GHG protocol scopes and emissions

3. Methodology

This chapter narrates the method that was used in this thesis to answer the research questions. It describes the research design, data collection, data analysis and research quality.

3.1 Research design

A research design is the framework that is used for data collection and data analysis to answer the research questions that are formulated (Bryman and Bell, 2011). Since the purpose of the thesis is to understand the barriers faced for sustainability implementation amongst lower-tier suppliers and how lower-tier suppliers monitor the sustainability of their sub-suppliers further upstream in the supply chain, the empirical findings were the main source of data to conduct analysis and develop solutions. An inductive approach was used as the results from the thesis contributed to the existing literature about lower-tier supply chain management. The case study approach was used as the research design. Although suppliers from the supply chain of two other companies are part of the thesis study, the majority of the primary data is from the main case company and hence this research design is referred to as a case study and not a multiple case study. Suppliers from the supply chain of two other companies in the same sector were included for comparison and validating purposes. Inclusion of suppliers from these companies helps convey an overall perspective of the sector in comparison to a single case study.

Initially, the topic of carbon net zero and its connection to lower-tier suppliers and barriers for decarbonization in LTSM was explored through a literature survey. Capgemini, an IT-services, and consulting company was selected as the case for this thesis study. Previous papers have focused on other industries like construction, manufacturing, energy, and fashion. There are very few papers focusing on the IT-services and consulting sector. Since this industry works in synergy with other industries, it was a sector that had to be studied. The IT-services and consulting company selected as the case company will be referred to as company X in the report. However, as discussed in earlier sections, majority of emissions in a company's supply chain occurs at lower-tier suppliers who are located upstream in the supply chain. Studies have explored various industries and sectors to identify barriers for supply chain decarbonization. There are very few articles on supply chain decarbonization in the IT services and consulting sector. After selecting the case, an interview was conducted with the supervisor at company X. The interview helped define the purpose of the thesis

study and formulate the research questions. The data collection started after finalizing on the research questions. Verbal surveys also called interviews and written surveys which are questionnaires were used for data collection (Glascow, 2005). Data was simultaneously collected from various lower-tier suppliers in the form of responses from the questionnaire. Suppliers who obliged for a telephonic interview were interviewed. The findings were analyzed to find trends in data and were categorized based on the theme and research questions in mind. The data collected was used to answer the research questions. Finally, recommendations were presented by comparing the trends in the data with available literature that is already presented in the previous chapter and conclusions were drawn. Figure 4 is a pictorial representation of the methodology used for this thesis study.

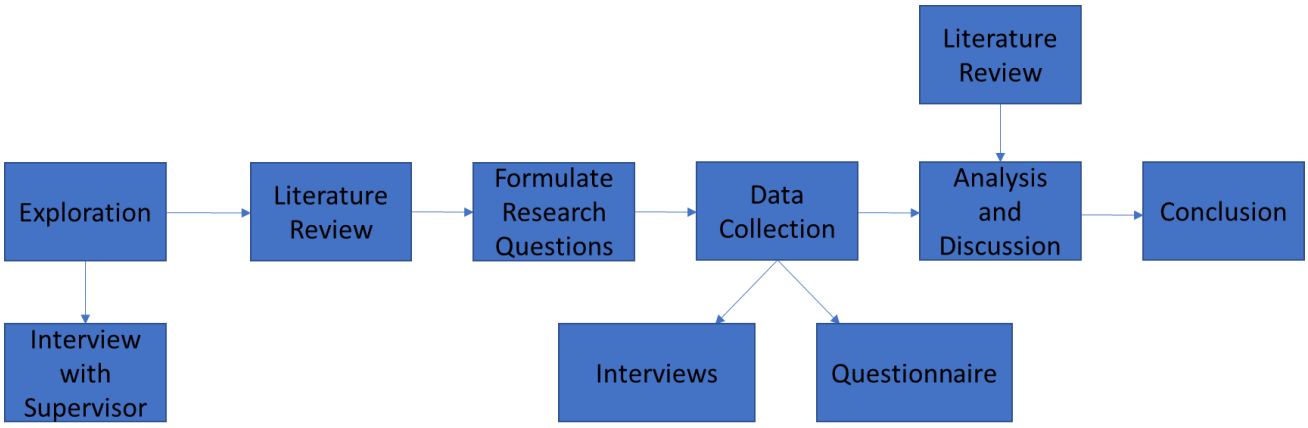

Figure 9: Methodology used for thesis study

3.2 Literature review

Literature has been used throughout the course of this thesis study for various purposes. Literature was used initially set a foundation to the thesis study by helping understand the problem and for developing relevant research questions. Later, literature review was used to identify existing publications on barriers for supply chain decarbonization involving implementation of SSCM in LTSM.

The theoretical background in chapter 2 is based on articles, journal papers and scientific papers gathered mainly from Google Scholar and other redirected websites like Springer, Emerald and ScienceDirect using access from Chalmers library. Papers related to decarbonization and barriers for decarbonization in LTSM were the focus. Websites also played a crucial part of the

development of the theoretical background of this thesis study. The literature related to concepts of carbon net zero and scope 3 emissions were mainly accessed from the reports available in the respective websites. The keywords used during the entire literature review process were: “carbon net zero”, “sustainable supply chain management”, “multi-tier supply chain management”, “lower-tier supplier management” and “scope 3 emissions”.

3.3 Case description

The case company has vowed to play a leadership role in ensuring that they implement measures for sustainability internally and also help their other clients which include suppliers, policymakers, and governments to make a sustainable progress towards carbon net zero and therefore aligning with the climate goals in accordance with the Paris Agreement. Company X was amongst the first companies in the IT services sector to have their carbon reduction targets validated by the Science-Based Targets Initiative (SBTi). The case company has developed a strategy towards carbon net zero by implementing carbon reduction in key impact areas. The key impact areas include energy, travel, carbon removal offsets and supply chain. The strategies are ambitious but the main hinderance for these strategies is the increase in the scope 3 emissions despite the results. Company X has also identified that their main emissions are scope 3 emissions. These emissions are occurring upstream in their supply chain at the lower-tier suppliers. The company has decided to address this issue by better engagement with their lower-tier suppliers to achieve their carbon net-zero goals. This will also help the company to provide adequate strategies and solutions to their clients who are facing the same issue of engagement with lower-tier suppliers. As the voice of the company, Aiman Ezzat, CEO of Capgemini has quoted “A sustainable future is achievable only with deep collaboration with our clients, suppliers, and other stakeholders” (Capgemini, 2022).

This thesis study was carried out under the Corporate Real Estate Services department (CRES) at the case company. This department is responsible for framing and ensuring the implementation of the ESG strategy of the company. Since this thesis was carried out to address the environmental sustainability aspect in the strategy, this was the most appropriate department. Another reason for conducting the thesis as a part of this department was because of the coupling of procurement with the sustainability team. Company X is one of the first companies to couple both sustainability and procurement teams together and work in a single team. This allows for a stricter implementation

of the sustainability the measures. This also helped this thesis work as establishing contact with the suppliers and supply chain interaction was extremely systematic.

3.4 Data collection

A qualitative approach was used for data collection. Primary data was collected by using a survey approach with the help of a structured questionnaire and interviews were also conducted. Much of the primary data obtained were from the responses to the questionnaire. This was because the lower-tier suppliers are in another country, and it is difficult for them to connect for an interview. There is also the language barrier. Lower-tier suppliers are often SMEs located in different countries and there is a problem with the language barrier. Secondary data was collected from scientific journals, internal company documents and existing literature.

Extensive literature survey was carried out on the decarbonization barriers involving SSCM implementation in the lower tiers of a supply chain. Based on the literature available, insights from the single interview conducted with the supervisor at company X and some help from the procurement team at the company, an Enterprise resource planning (ERP) software was used, and a list was made of the distinct categories or domains of material procured by an IT-services and consulting firm. The ERP software was the right tool to use for identification of various categories as all the data involving suppliers linked to the company is available in the software. The use of ERP software enabled access to all departments in the organization. Since the upstream activities include suppliers of both direct and indirect material, all the categories of both direct and indirect material categories were identified to get a holistic understanding of all actors involved in all tiers in the supply chain. Although the share of material procurement is different for different categories identified, the involvement of all departments will help achieve more accurate results. The distinct categories identified were:

- Packaging
- Fleet suppliers
- Hardware
- Software
- Building materials
- Building equipment

- Energy suppliers
- Furniture
- Consumer goods

Once the categories were identified, a flowchart was developed to reach out to suppliers for data collection. Along with the help of the procurement team at the company, since the case company has operations in three regions – USA, Europe and Asia, the method of cluster sampling was used. Lower-tier suppliers from the European and Asian regions were chosen randomly from, various categories to participate in this study and treated as two clusters –Asia and Europe. The reason for selection of these two regions is because company X is headquartered in the European region and the main operations are carried out in Europe. The operations in Europe are in developed countries. However, the company's 50% workforce includes professionals employed in India (Asia). There are currently 200,000 employees in India. Since India is a developing country, it would be interesting to get perspectives from both the regions. Data sets from both these regions will help the company get an insight about supplier selection based on geography.

A minimum of two suppliers were selected from each identified category to ensure that the data collected is not a one-off response. At least more than one supplier was selected from each category so that the data can be compared with other suppliers in the same category. This helps both the company and the supplier. The company benefits by acquiring knowledge about which supplier has a better sustainability performance. This will help them procure more from the supplier adhering to the requirements. From the supplier's perspective, this comparison will help them understand how their competitors are performing and will provide insight on areas of improvement. With the help of first-tier suppliers of the above identified categories, contact was established with their sub-suppliers (Tier 2 and Tier 3 suppliers). The categories from which company X procured a high percentage of goods were given importance and a greater number of suppliers were reached out to in these categories. Buildings comprised the maximum share of material procured by company X. This data was accessed using the ERP software. The buildings category was split into two sub-categories: buildings materials which included the raw material and constriction related goods; building equipment which included all the equipment installed in the premises and required for the functioning of the building. This included heating, ventilation, and air conditioning

equipment, maintenance equipment, lighting, elevators, and ducts. Building equipment category has the highest percentage of procurement.

Suppliers were selected from all tiers in the supply chain. Since building equipment is the most procured category, equal number of tier 2 and tier 3 suppliers (four from each tier) were chosen to take part in the thesis study. Unfortunately, one of the tier 3 suppliers could not take part in this thesis study due to global supply chain problems occurring due to the war in Europe. The main objective in the other categories was to select at least one supplier from either tier 2 or tier 3. This was to develop a comparison of the performance in the different tiers. Reaching out to raw material suppliers is very difficult as they avoid any kind of attention. Luckily, two raw material suppliers from Asia agreed to take part in this thesis study. Existing literature says that implementation of sustainability is challenging further upstream in the supply chain. By collecting data from tier 2, tier 3 and raw material suppliers, this issue can be verified. The suppliers taking part in this thesis study are all suppliers to the IT-services and consulting sector. Out of the 30 suppliers, 21 of the suppliers belonged to company X, seven of the suppliers belonged to the supply chain of Accenture and two suppliers belonged to the supply chain of Schneider Electric. The inclusion of suppliers from supply chain of other global companies in the same sector gives company X an idea about how its competitors are managing their supply chain. This will help company X understand the difference in approach and strategy.

The contact was made to tier 2 and tier 3 suppliers through a known contact in Accenture. The suppliers were willing to participate in this thesis study after the understood the implications of the thesis. The person who helped establish contact was a senior vice president - business solutions and strategy. The contact with suppliers belonging to Schneider Electric was made with the help of the manager – digital buildings. This person was also one of the interviewees for this thesis study.

Figure 5 shows the flowchart with the approach used to establish contact with suppliers across various tiers of supply chain of company X.

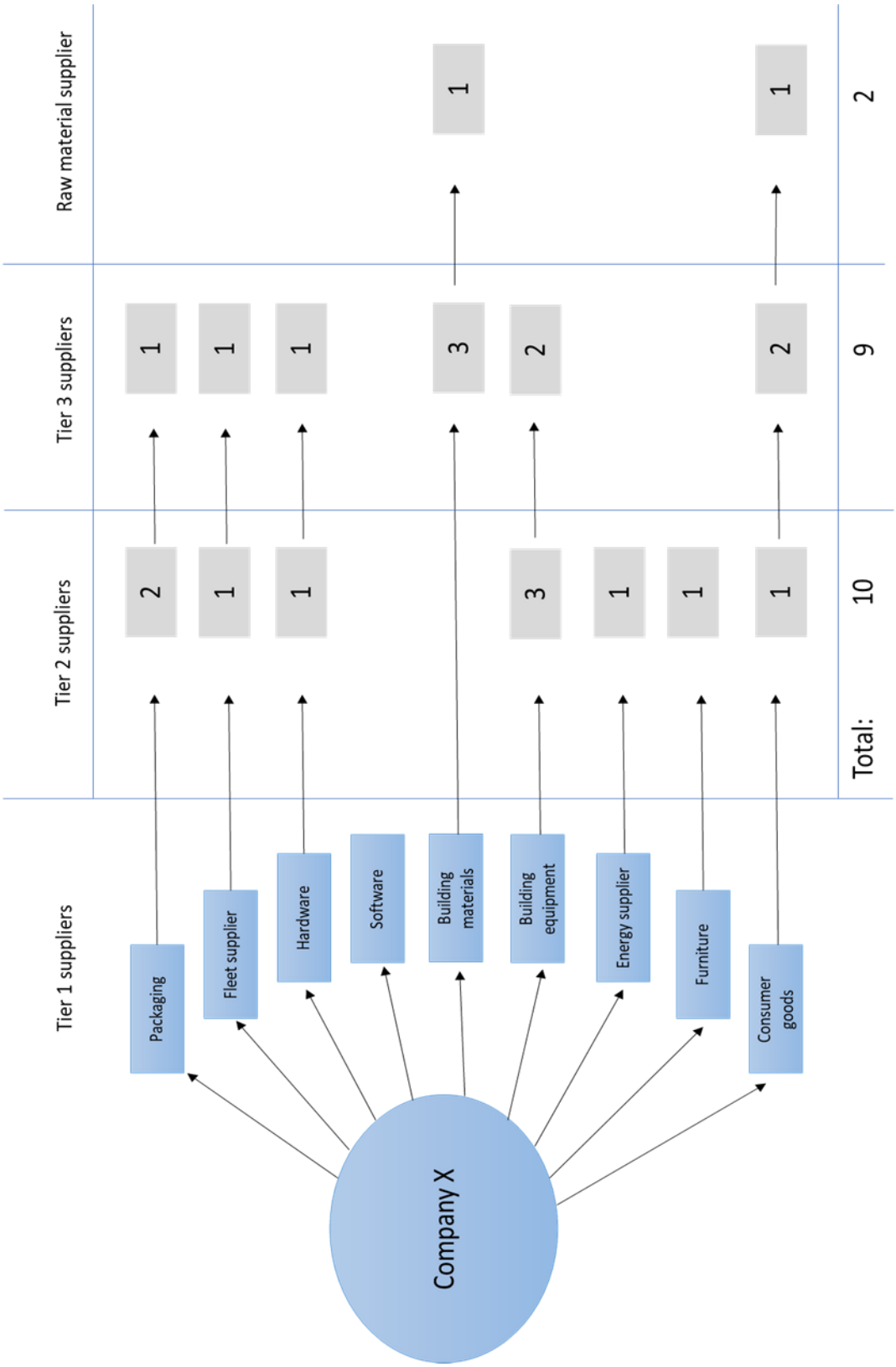

Figure 10: Representaion of the flowchart used to establish contact with suppliers in the supply chain of Company X

3.4.1 Interviews

The interviews helped to get the perspective of the lower-tier suppliers and validate existing literature. Interviews were conducted amongst lower-tier suppliers from both the regions and in different domains to get a perspective of lower-tier suppliers from two different geographies.

The interview with the supervisor at case company X was an unstructured interview as it was more an exploratory interview. The supplier interviews were semi-structured. The questions were sent to the lower-tier suppliers well in advance in the form of a questionnaire via email. This provided the supplier enough time to prepare for the interview. The answers to the questions in the interview were taken down in the form of notes so that the responses can be transcribed later.

Two different interviews were conducted. Table 1 provides an overview of the interviews conducted. Two different templates were created for the two different interviews: one for the interview at company X and the other template for the interviews with the lower-tier suppliers. The interview conducted at case company X provided insight about the challenges faced by the company to engage with the lower-tier suppliers in the company's supply chain. It provided very important insight about the sustainability requirements of the company from the suppliers located in all tiers of the supply chain. The interview provided information of the environmental management system framework at company X, supplier code of conduct, supplier assessment strategy, sustainability requirements, sustainability standards, sustainability parameters for sustainability reporting, restricted list of substances and other sustainability related data. The supplier interviews were conducted to validate the barriers that were discussed in the literature and investigate if the lower-tier suppliers were aware of the sustainability requirements of case company X. Interviews with the suppliers also helped understand the barriers they faced to practice sustainability internally, amongst their sub-suppliers and their current practices to monitor sustainability performance of sub-suppliers. The interview with the supervisor at company X was conducted via zoom. All the interviews with the lower-tier suppliers were conducted via a telephonic interview as lower-tier suppliers were in a different country. All the interviews were conducted in English.

Table 1: Overview of interviews

Interview	Date	Time (mins)	Interview category	Subject	Designation of the interviewee	Region	Product	Domain	Company
1	3/21/2022	90	Internal interview at case company X	Interviewee 1	Senior Director - Corporate Real Estate Services	-	-	-	Company X
2	4/13/2022	30	Tier 3 supplier	Interviewee 2	Manager sales	Asia	UPVC Windows and Doors	Building materials	Company X
3	4/25/2022	30	Raw material supplier	Interviewee 3	Manager supply and operations	Asia	Cement	Building materials	Company X
4	5/13/2022	30	Tier 2 supplier	Interviewee 4	Manager - Digital buildings	Europe	HVAC	Building equipment	Schneider Electric
5	5/16/2022	30	Tier 2 supplier	Interviewee 5	Manager Circular operations	Europe	Cutlery, plates and cups	Consumer goods	Company X

3.4.2 Sampling of interviews

The interview conducted at the case company X was selected based on the designation to get a complete understanding of the challenges faced by the organization by lower-tier suppliers' sustainability performance and governance. The interview was an unstructured interview and it helped understand the challenges, define the purpose of the study, understand the sustainability requirements of the company, and formulate research questions. This interview also helped formulate questions for the semi-structured interviews conducted with the lower-tier suppliers.

To answer the research questions formulated, the suppliers were chosen from regions Asia and Europe based on cluster sampling. These two regions were selected as the company has operations in both these regions. Also, since suppliers in the European region are part of a developed economy and that of Asian region are part of a developing economy, this clustering would help understand if geography is an important factor for lower-tier supplier selection. The suppliers in the two selected clusters were selected randomly based on the categories of procurement identified. Since buildings are the most procured category, emphasis was given to this category and three of the four interviewees belonged wither to building equipment or building materials category. The suppliers were selected based on their position in the supply chain. A supplier was chosen from each of the lower-tiers – Tier 2, Tier 3 and Raw material supplier- to get the perspective from

suppliers located in all tiers of the supply chain. Interviewee 5 was reached via LinkedIn using the help of the tier 1 or direct supplier. A person from the procurement team at the company helped establish contact with the tier 1 supplier. The tier 3 supplier was contacted by email and contact was established based on the reference of a tier 2 supplier. Contact was established via email with the raw material supplier as well. Due to lack of time, only one supplier from each tier in the supply chain could be interviewed.

3.4.3 Questionnaire

Questionnaires are important tools that are used by companies and organizations to gather data related to performance as there is no pressure on the participant to answer the questions in a required manner as there is lack of direct contact (Glascow, 2005). A questionnaire was used for majority of the primary data collection. Questionnaire was used to reach a larger number of lower-tier suppliers from regions A and E. Responses from a larger population helped in validating responses from the interviews and the discussions from available literature. An online Microsoft form was created in the form of a questionnaire.

Questions were created based on literature and topics discussed during the interview with supervisor at company X. The questionnaire was first sent out to a handful of tier 1 suppliers via email with a link to the form. This pilot test run helped negate any misunderstandings and get feedback from them. The questions were developed based on the theoretical background so that the data can be easily split into different themes and categorized for analysis. The questions in the questionnaire were the same questions used for the interviews. This was helpful in connecting data to theories and drawing comparisons.

The questionnaire contained 12 questions. The first two questions in the questionnaire were a set of open-ended questions to investigate the general understanding of environmental sustainability and knowledge on the same. Questions three to eight were close-ended questions focused on obtaining results to answer the research questions and were based on critical concepts related to barriers for SSCM implementation, environmental standards, and environmental sustainability. These questions were based on the sustainability requirements of the company as discussed during the internal interview at company X. Finally, the last three questions of the survey were open-ended questions and focused on the understanding amongst the lower-tier suppliers about customer

perspective and carbon net-zero. The questionnaire could be submitted only after all the questions were answered. The questions contained in the questionnaire can be found in Appendix A.

The questionnaire was circulated to the tier 2 suppliers in each of the regions and was also distributed amongst their sub-suppliers. The sampling was done randomly to choose suppliers in each of the two regions amongst various domains identified but preference was given to the building equipment category. With the help of the procurement team and the interviewee's, an email was sent to 25 lower-tier suppliers in the Asian region and 12 lower-tier suppliers in the European region. The email consisted of a short description about the background of the thesis study. The hyperlink leading to the questionnaire was attached in the email. A QR code which could be scanned to navigate to the questionnaire was also attached in the email. The survey received 30 responses in total from lower-tier suppliers in both two regions. 19 out of 25 suppliers were from the Asian region and 11 out of 12 suppliers belonged to the European region. The response rate was 76% in the Asian region and 91% in the European region. Table 1 represents the list of lower-tier suppliers who participated in the research survey.

Table 2: Questionnaire respondents

Supplier	Position in supply chain	Region	Domain	Company
S1	Tier 2 supplier	Asia	Hardware	Company X
S2	Tier 2 supplier	Asia	Software	Accenture
S3	Tier 3 supplier	Asia	Hardware	Company X
S4	Tier 2 supplier	Asia	Energy supplier	Company X
S5	Tier 3 supplier	Asia	Building equipment	Company X
S6	Tier 3 supplier	Asia	Consumer goods	Accenture
S7	Raw material supplier	Asia	Consumer goods	Company X
S8	Tier 2 supplier	Asia	Fleet supplier	Accenture
S9	Tier 2 supplier	Asia	Fleet supplier	Company X
S10	Tier 2 supplier	Asia	Packaging	Company X
S11	Tier 2 supplier	Asia	Building equipment	Accenture
S12	Tier 3 supplier	Asia	Fleet supplier	Company X
S13	Tier 3 supplier	Asia	Hardware	Accenture
S14	Tier 2 supplier	Asia	Furniture	Accenture

S15	Tier 3 supplier	Asia	Building materials	Company X
S18	Tier 3 supplier	Asia	Packaging	Company X
S19	Tier 2 supplier	Asia	Energy supplier	Accenture
S20	Tier 2 supplier	Europe	Software	Schneider Electric
S21	Tier 2 supplier	Europe	Building equipment	Company X
S22	Tier 3 supplier	Europe	Consumer goods	Company X
S23	Tier 3 supplier	Europe	Building equipment	Company X
S24	Tier 2 supplier	Europe	Building equipment	Company X
S25	Tier 2 supplier	Europe	Furniture	Company X
S26	Tier 2 supplier	Europe	Packaging	Company X
S29	Tier 3 supplier	Europe	Building equipment	Schneider Electric
S30	Tier 3 supplier	Europe	Building materials	Company X

3.5 Data Analysis

The data analysis was carried out in five steps:

1. Filtering data from the interviews
2. Development of themes
3. Categorize data into themes based on codes
4. Combining data from interviews and questionnaire
5. Form theories and validate with literature

The analysis began by filtering the data collected from the interviews. The internal interview with interviewee 1 provided was the first interview conducted in the initial stages of the thesis study. This interview was analyzed as the first part of the thesis study. The initial questions were focused on the general understanding of sustainability. The response was filtered into different categories based on their importance. More attention was focused on the challenges faced by the company because of lower-tier supplier sustainability performance and the sustainability requirements of the company from all tiers of the supply chain. This data helped to explore existing literature related to this topic. After comparing the requirements with existing literature, research questions were formed.

Since the problem was well defined and the research questions were defined, there were some pre-anticipated results expected from the interviews with the lower-tier suppliers. So, different themes were developed before the lower-tier supplier interviews were conducted. The different themes that were developed were: *Implementation and Monitoring*. Under these two themes, sub themes that were developed keeping in mind the research questions were *Barriers* and *Strategies*. The responses from the notes of interviews of the lower-tier suppliers were recorded in a Microsoft word file and stored so that they can be accessed at any point of time during the thesis study.

The questionnaire was circulated as a Microsoft form and the responses to the questionnaire from the lower-tier suppliers were recorded as an excel file based on the questions. Descriptive coding approach was implemented to sort data based on the different themes that were developed based on the research questions that had to be answered and based on the expectation from the collected data. Coding approach was based on a bottom-up approach where concepts were identified from the data collected and not pre-determined. The responses from the questionnaire were saved as an excel spreadsheet so that it could be accessed whenever required. Once the themes were developed, there were codes assigned to the data based on the responses and the appropriate codes were sorted under the respective themes that they represent. Coding was done based on the expected outcomes that was explored through literature and from the responses received during the interviews. Keywords related to sustainability were used as codes to segregate the data into *Barriers* or *Strategies* categories. Examples of a few codes used are high cost of recycling, conducting audits, lack of knowledge, lack of expertise. Wherever required, codes were further split into sub codes for accurate segregation of data. The responses were coded and sorted based on the themes.

The responses from the interview were coded and sorted in the excel spreadsheet under the different themes developed. The data obtained from the response to the questionnaires were coded and sorted. Now, all the data obtained both from interviews and responses to the questionnaire were in the same format in an excel spreadsheet. The categorized data was compared with existing literature and research questions in mind to identify trends based on the themes. Careful examination was done to identify any connection between two different themes.

3.6 Research Quality

The validity and reliability of collected data is an important aspect to consider when discussing about the quality of the study (Bryman and Bell, 2011). Validity and reliability that have been considered in this study to construct a quality study have been discussed along with ethics in this chapter.

3.6.1 Validity

Data validity can be assessed based on internal and external validity (Bryman and Bell, 2015). In this thesis study, the responses from the suppliers have been discussed with the supervisor at company X. This was done to validate if the results were appropriate. The thesis study has also incorporated concepts that were discussed which is a part of the sustainability reports of the company. The concept of carbon net zero and how it is connected to lower-tier supplier management (LTSM) is clearly developed and defined.

The data was collected from 30 different lower-tier suppliers. Four interviews were conducted amongst the 30 suppliers. The data collected from multiple suppliers enhances the chances for data to be generalized. Although this thesis study is conducted in a particular industry, the findings of this study is relevant for all other industries struggling to engage and monitor the sustainability performance of their lower-tier suppliers.

3.6.2 Reliability

This thesis study was highly dependent on the topic of focus and has revolved around responses collected from semi-structured close-ended questions. The thesis study is also time dependent as the concepts considered and the responses received are based on the available technologies today and based on the development in the topic of interest. This will change with time. This means that the study can be replicated by using the same set of parameters used in this thesis study but at a future point in time.

The questions in the questionnaire were developed before the questionnaire was circulated. The questionnaire was first sent out to a handful of tier 1 suppliers via email as a pilot test run helped negate any misunderstandings. Following the approach suggested by Kitchenham and Pfleeger

(2003), the responses are checked for any inconsistency or incompleteness. To avoid the incompleteness aspect, responses to all the questions in the questionnaire were made mandatory.

3.6.3 Ethics

Before the interviews, the interviewees were informed about the purpose of the study, their contribution to the research and that the responses will be anonymous. All the responses collected through the questionnaire were also anonymous to preserve the privacy of all the suppliers involved in this study. The Microsoft form in the form of a questionnaire also had a clear description of the purpose of the study and clearly stated that the responses will be anonymous in accordance with the General Data Protection Regulation (GDPR). Lastly, the description also mentioned that the final recommendations of the study will be circulated to the first-tier suppliers in the company who will circulate it to all the tiers of suppliers.

4. Empirical data

Empirical data will be presented in this chapter of the report. The empirical findings are presented based on the data received from the interviews and questionnaire. The empirical data is structured around the research questions and will be presented on the two main themes that were used to categorize data: Implementation and Monitoring.

4.1 Implementation of sustainability

Firstly, the following section presents the barriers faced by lower-tier suppliers for implementing environmental sustainability measures in their operations. The findings from the interviews and the questionnaire of lower-tier suppliers of company X are presented along with the findings of suppliers belonging to two other companies in the same sector. Lastly, the section will present the current strategies adopted by lower-tier suppliers for implementation of sustainability measures in their operations.

4.1.1 Barriers for sustainability implementation

The following section covers the barriers faced by lower-tier suppliers for implementation of environmental sustainability measures in their operations. The results can be presented based on two major groupings: internal barriers and external barriers. The main internal barrier was cost. The external barriers were lack of awareness of the sustainability requirements. This section will present the barriers faced by lower-tier suppliers in taking up sustainable practices. First, the internal barriers will be presented followed by the external barriers.

4.1.1.1 Internal barriers

Cost is clearly the main barrier for lower-tier suppliers to take up sustainable practices. From the responses to the interviews and questionnaire, almost 83% of the lower-tier suppliers have answered that cost is the most significant barrier for sustainability implementation. More than 80% of the lower-tier suppliers have answered that the main motivations for selecting cost as a barrier was due to the high set up cost of an environmental management system (EMS) and that procurement of clean energy is expensive.

The lower-tier suppliers have mentioned that the *high cost of implementation of EMS* is one of the main motivations for selecting cost as a barrier. The lower-tier suppliers mention that continuous evaluation tools to assess the environmental impact of operations of these suppliers is very expensive and requires constant capital. One of the suppliers mentioned "The capital required upfront for establishing EMS is extremely high. Even though this initial investment is arranged using some help, to sustain this model more capital is required to train the staff constantly based on changing requirements. As SMEs it is extremely difficult to allocate capital to EMS implementation. It can be implemented effectively only if the buyer is willing to support the capital requirement". Another repeated reason that motivated the suppliers to mention high cost for EMS implementation was the high initial cost of sustainable materials. A supplier of building equipment mentioned "Procuring is sustainable materials is at least three times more expensive compared to normal materials. There are currently very few suppliers of sustainable material. Due to their ties with some large organizations, the price of the materials is capped at the price that these large organizations pay and hence it is not affordable for us. On top of the high price of materials, these sustainable materials are available mainly in specific countries and therefore import duty must be paid along with the shipping cost". The lower-tier suppliers mentioned that implementation of EMS demands the suppliers to hold licenses and permits for various standards and requirements like the ISO 14001 for EMS. Obtaining these licenses and permits are expensive. Interviewee 3 mentioned "Obtaining licenses to meet the sustainability standards are not only time consuming but also expensive".

The lower-tier suppliers mentioned that *renewable energy is expensive* and difficult to procure. When asked about the motivation behind the barriers, interviewee 3 mentioned "As a raw material supplier, the expectations are to use clean energy and low carbon equipment for operations of raw material extraction. The procurement of clean energy is expensive. Our operations require a huge amount of clean energy and this it is not cost competitive to use complete clean energy to satisfy this energy demand. Clean energy is also not available whenever required in the country we are located". Two suppliers mentioned that their location does not have access to the grid that has renewable energy mix. So, to get access to the grid with renewable energy mix they must make a huge investment to establish a distribution network. This cannot be done by the suppliers, and they will have to pay the local government to get the transport infrastructure in place. Some lower-tier suppliers mentioned that the investment cost for installation of on-site renewable energy

generation is extremely high. They mentioned that the return-on-investment period for their investment was long. One out of the two suppliers who answered that they do not have access to grid that has renewable energy mix mentioned that they had explored the option of implementing on-site renewable energy generation as it was cheaper in comparison to paying for transportation infrastructure. But they mentioned that the overall cost of operating the on-site was very expensive. The supplier mentioned "We explored on-site renewable energy generation by installation of rooftop solar PV panels. Although the investment cost was high, it was cheaper compared to other available options. But since solar energy generation is varying, the setup required an energy storage system to store additional energy produced. The battery storage systems currently available are extremely expensive".

Another repeated mention from the lower-tier suppliers was that of *uneconomical recycling* and *high cost of low carbon technology*. The lower tier suppliers mentioned that even though they use recyclable packaging, the cost of packaging transportation for disposal and recycling were very high. Another important mention by lower suppliers that was coupled along with recycling and low carbon technology was the customer perspective. The lower-tier suppliers mentioned that the customers are not willing to pay an additional price for a low carbon product causing a cost burden to lower-tier suppliers. Interviewee 5 mentions cost as the main barrier for implementation of sustainability. Interviewee 5 mentioned "We are suppliers of cutlery and cups, and the main mode of sustainability implementation is through implementation of recycling both in the product as well as packaging. The current recycling technologies are not cost efficient. The recycling rates are very high and implementation of recycling in all our operations will result in a significant increase in the overall cost of the product". Interviewee 4 quoted "Sustainability is becoming a new requirement more than just a trend. We are currently trying to be more sustainable in our operations. But the main barrier is the high cost of investment for low carbon technology. We are okay investing more money if we are getting better returns. But the clients are not willing to increase the cost and pay more. There must be better incentives for overcoming cost to drive us for complete implementation of low carbon technology". Many lower-tier suppliers mentioned that due to lack of development and implementation of low carbon technologies, the current technologies are very expensive and are not affordable for SMEs.

Table 3 summarizes the main motives for the lower-tier suppliers for the choice of selection of cost as the internal barrier for taking up sustainable practices.

Table 3: Summary of motives for selection of cost as the main internal barrier

Reasons for selecting cost as a barrier
• Expensive to set up Environmental management system (EMS) • Procurement of renewable energy is expensive • Low carbon technology has high investment cost • Uneconomical recycling • Customers not willing to pay additional price for a low carbon product • Obtaining certificates and licenses/permits are expensive

4.1.1.2 External barriers

Lack of awareness about the sustainability requirements is one of the most mentioned barriers by lower-tier suppliers. 37% of the lower-tier suppliers mentioned that they have been affected by these external barriers for sustainability implementation. The data related to external barriers for sustainability implementation can be presented under two main categories: *lack of knowledge about the sustainability standards and requirements* and *difference in regulations in different countries.*

Lower-tier suppliers mention that they have *no knowledge about the sustainability requirements* of the focal company as they often do not bother to ask their clients about whom they are supplying the product to. Interviewee 2 mentioned “We do not have the required knowledge about the sustainability requirements of the company. We are just following the word of mouth about sustainability implementation and do not have the actual knowledge about areas that require sustainability implementation. Since we are not clear about the requirements, we are not in a position to enforce any requirements on our sub-suppliers”. The suppliers mentioned that they do not have the *knowledge to conduct audits* by themselves. Interviewee 2 mentioned that the main resource barrier was “We do not have the required knowledge about the sustainability

requirements. Even if we understand the requirements, it is very difficult to train people in the organization to conduct audits". Lower-tier suppliers also mentioned that

The lower-tier suppliers are affected by *different regulations in different countries*. They mention that countries in the EU demand strict regulations, but they are often not aware of these as they are in Asia. They mention that even though they meet the requirements of their respective country, they fall short of the requirements of the country in which the focal company is located. And they emphasize that there is no incentive for them to try to follow regulations of the country in which the focal company is located as the only thing that is monitored and that matters are if they are meeting the requirements of the country in which they are located. Interviewee 2 mentioned "The difference in regulations and requirements between Asia and Europe has affected us the most. We are currently meeting all the requirements in the country we are located. But our client located in Europe wants us to get additional certifications that are according to the environmental policy followed in Europe. These certifications will cost us a lot of money and resources".

Table 4 summarizes the main external barriers faced by lower-tier suppliers for taking up sustainable practices.

Table 4: Summary of external barriers faced by lower-tier suppliers

External barriers faced by lower-tier suppliers
• Lack of knowledge • Lack of resources to conduct audits • Different regulations in different countries • Less strict regulations in countries. Therefore, even though regulations in that country are followed, it is not enough to meet the requirements

4.1.2 Strategies for sustainability implementation

The following section covers the current strategies adopted by lower-tier suppliers for implementation of sustainability in their operations. The focus is to present the practices adopted in different areas to achieve environmental sustainability.

27 out of the 30 suppliers who took part in this research survey have initiated the process to take up sustainability by *calculating their carbon footprint*. The suppliers mention that they have started calculating the carbon footprints of their individual products as well as the total carbon footprint of their factories or manufacturing buildings. Five out of the 27 suppliers also mentioned that they are considering the carbon emissions from the transportation of inflow and outflow of materials as well in their carbon footprint calculations.

11 suppliers mentioned that they have started *electrifying the fleet* that they use for company related travel. Five out of these 11 suppliers mentioned that they have also electrified the complete fleet that is used by them for transportation of goods. Seven suppliers mentioned that they have started using electricity for heating applications instead of fossil fuels. They mention that they are not yet bothered by the origin of the electricity but by transitioning to complete electricity, they have an opportunity in the future to shift to renewable sources of energy.

23 suppliers mentioned that they have replaced their factories with *100% LED lighting*. They mention that this is a very good approach for carbon neutrality. They mention that this was possible because of the reduction in price of LED's. They also mention that lights in not commonly used places are sensor operated and switch on and off based on the activity in that area. In addition to installation of LED lighting, these 23 suppliers also mentioned that they have invested in *workplace insulation*. They have mentioned the use of airtight windows, air curtains in open areas and other measures to ensure more efficient heating or air conditioning.

16 suppliers mentioned that they have purchased *new machinery* that is *more energy efficient*. They mentioned that the newer machines consume less electricity and have better efficiency. One supplier mentioned "By installing new CNC machines made in Germany in our manufacturing factory, the energy consumption of the factory has reduced by 22% in the last one year". 12 suppliers mentioned that they have *switched to renewable energy* as a measure to achieve carbon

neutrality. Three of the 12 suppliers who have switched to renewable energy mentioned that most of the general lighting appliances in the workplace is completely powered by renewable electricity. One of the suppliers mentioned "Currently all lighting appliances run on renewable electricity. We are investing in new energy efficient machinery that require less energy. By transitioning earlier, we are making it possible to have the entire factory including machinery to run on 100% renewable energy. We have also completely shifted to electricity usage for heating applications". Four suppliers mentioned that they have achieved noticeable energy savings by switching to renewable energy as the main source of electricity. They mentioned that this transition is proving to be extremely economical in current scenarios where the energy from fossil fuels is extremely volatile and unpredictable.

Five suppliers mentioned that they have switched to sustainable *reusable designs* so that they energy and electricity consumption can be reduced. Table 5 summarizes the different measures for carbon neutrality adopted by suppliers.

Table 5: Summary of strategies implemented by lower-tier suppliers for carbon neutrality

Implemented strategies for carbon neutrality
• Calculating carbon footprint • Electrification of fleet used for business travel • Electrification for transportation • Use of electricity for heating instead of fossil fuels • Workplace insulation • Use of 100% LED lighting • Investment in energy efficient machinery • Switching to renewable energy • Reusable design

19 of the 30 suppliers have answered that they have an *EOL policy* in place. There was another sub question to this main question in the questionnaire if the EOL policy included the ISO 14001,

ROHS and REACH compliance. All the suppliers have responded that their EOL treatment policy includes all the compliance standards.

Six suppliers mentioned that they use plastic in one form or the other as their packaging material. They mentioned that the main reason for them to not switch to *sustainable packaging material* alternatives was because it would compromise the safety of the product. Six suppliers mentioned that they use packaging made from recycled paper. They mentioned that the recycled paper packaging was cost effective because of the ease of availability in their locations, and they also received incentives from their clients for using recycled paper packaging. 16 suppliers mentioned that they use cardboard packaging. The reason for using cardboard packaging was because cardboard is versatile and suits a wide range of applications. Another motivation was because cardboard is completely recyclable and recycled carboard retains the quality of the original cardboard.

Out of the 16 lower-tier suppliers who have responded that they have implemented either *reusing, recycling or refurbishing strategies* in their operations, the suppliers mentioned that they reuse the cutting tool material multiple times in their operations. Another supplier of furniture mentioned that most of the furniture they receive either has a potential to be reused or if the wooden furniture has reached the EOL, they recycle the entire furniture, and the recycled wood is used in other products. Most of the other suppliers mentioned that they use reusable packaging. One of them has developed an incentive where they provide an additional cashback when the buyer returns the packaging so that it can be reused. Table 6 summarizes the strategies implemented by lower-tier suppliers to enforce recycling, reuse, and refurbishing.

Table 6: Summary of strategies implemented by lower-tier suppliers for recycling, reuse, and refurbishing

Implemented strategies for recycling, reuse, and refurbishing
• Reusing the cutting tool during manufacturing • Reusable packaging • Reusing wood from furniture that has not reached EOL • Cashback system for returning original packaging

4.2 Monitoring sub-supplier sustainability

Firstly, the following section presents the barriers faced by lower-tier suppliers for monitoring the sustainability performance of their sub-suppliers. Lastly, the section will present the current strategies adopted by lower-tier suppliers for monitoring the sustainability performance of their sub-suppliers.

4.2.1 Barriers for monitoring sub-supplier sustainability performance

The following section presents data about the barriers faced by lower-tier suppliers for monitoring sub-supplier sustainability. The data can be discussed based on two categories: *Sustainability as a criterion for sub-supplier selection* and *Monitoring barriers*.

More than 60% of the lower-tier suppliers have mentioned that they do not have sustainability as a criterion for choosing their sub-suppliers. The interviews gave a better understanding about why lower-tier suppliers do not have sustainability as a criterion for choosing their sub-suppliers. Interviewee 3 mentions that one of the main reasons for suppliers not having sustainability as criterion was because there were no alternate suppliers in a cost perspective. Interviewee 4 mentioned that giving importance to strategic sourcing based on sustainability as a criterion would result in a trust conflict with the existing suppliers with whom they have had a long-term relationship. Interviewee 4 also mentioned that their current sub-suppliers are selected based on cost efficient strategy and a deviation to search for sub-suppliers based on sustainability as a criterion would result in change in operational strategy and prove to be expensive. Interviewees 2 and 5 mentioned that discriminating sub-suppliers based on sustainability as criterion would affect the overall growth of the organization. They mentioned that sub-supplier base is critical for their operations and following sustainability as a criterion would result in a decrease in the number of available options narrowing their sub-supplier base. Narrowing their sub-supplier base would allow their competitors to have an edge.

The main reasons for lower-tier suppliers currently not monitoring their sub-supplier sustainability performance were the lack of resources and expertise. 60% of the lower-tier suppliers are currently not monitoring their sub-supplier sustainability performance. When asked about the reason for not monitoring sub-supplier sustainability performance, Interviewee 2 mentioned “We do not have the required knowledge about the sustainability requirements of the company and knowledge about

areas that require sustainability implementation. Since we are not clear about the requirements, we are not able to implement these sustainability measures in our organization. Since we cannot implement these measures, we are not in a position to enforce any requirements on our sub-suppliers". Interviewee 2 further mentioned "Since we do not have the required knowledge about the sustainability requirements, it is very difficult to train people in the organization to conduct audits". Another repeated mention was the lack of communication internally in the company. The suppliers mentioned that while training the staff, there was a lack of communication about the requirements due the lack of understanding of the requirements by the top management in the company.

4.2.2 Strategies used for monitoring sub-supplier sustainability

The following section presents data about the strategies adopted by lower-tier suppliers for monitoring sub-supplier sustainability. The strategy along with the method used to implement the strategy will be discussed in detail.

40% of the lower-tier suppliers are currently monitoring their sub-supplier sustainability performance. Figure 11 represents the share of lower-tier suppliers who are monitoring the sustainability performance of their sub-suppliers.

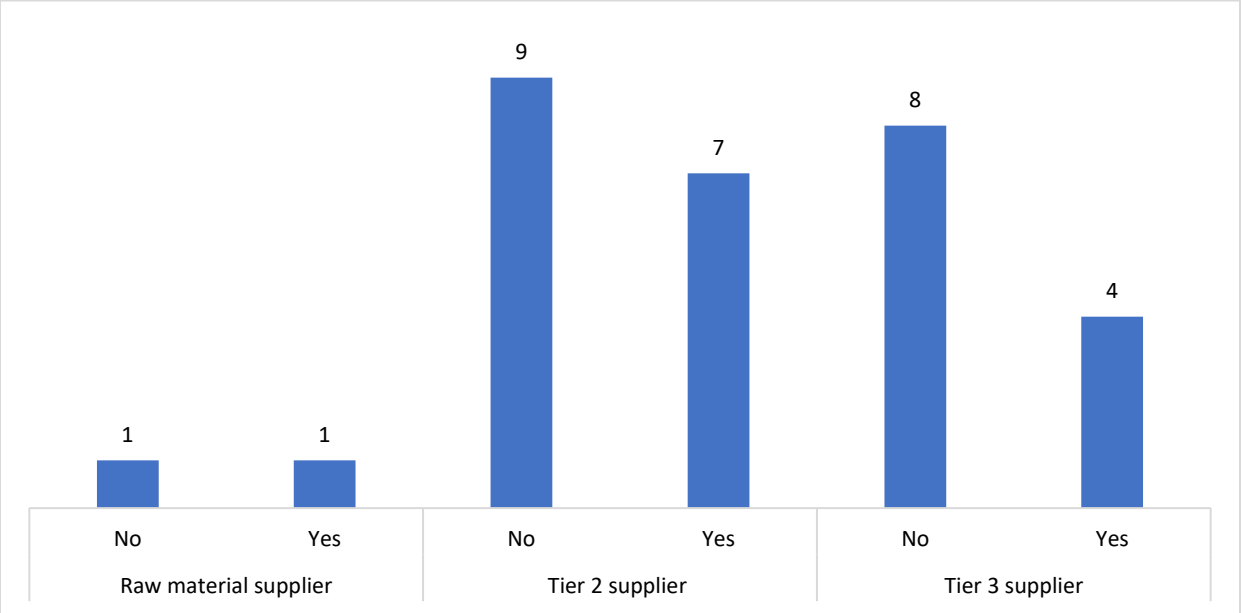

Figure 11: Summary of number of lower-tier suppliers monitoring their sub-supplier sustainability

Out of the 12 responses received from the lower-tier suppliers who are monitoring their sub-supplier sustainability performance, eight of the suppliers mention that they directly engage with their sub-suppliers to monitor their sustainability performance whereas the other four lower-tier suppliers mentioned that they do not engage directly and use a different strategy for monitoring.

4.2.2.1 Direct

Eight of the lower-tier suppliers mentioned that they directly engage with their sub-suppliers to monitor their sustainability performance. This means that these lower-tier suppliers communicate and directly monitor the sustainability performance of the sub-suppliers irrespective of the sub-supplier position further upstream in the supply chain.

Three of the eight suppliers mentioned that they have a team in place who are actively involved in inspecting the sites of their sub-suppliers. Interviewee 5 mentioned "We have a team that is responsible for reporting of sustainability data. The team conduct regular checks of all the sustainability related documents". Interviewee further mentioned "In order to enforce sustainability amongst our sub-suppliers we conduct quarterly audits". The suppliers mentioned that the team conducts quarterly audits to monitor and ensure that sub-suppliers are complying to the required sustainability standards.

Two suppliers mentioned that they are submitting an annual audit report to the sub-supplier to create awareness about the required sustainability standards. They mentioned that they submit the annual audit report so that the sub-supplier has a better understanding of the required standards. One of the suppliers mentioned "We update the sustainability requirements and provide our annual report of our sustainability performance to the sub-suppliers. This helps them understand the requirements and the scale of implementation that we expect from them. Also, to ensure that the sub-supplier is on track, we monitor their progress by conducting audits twice in a year. This helps us provide feedback and also ensure strict enforcement of sustainability". The suppliers following this strategy mention that they conduct audits of the sub-suppliers twice in a year to monitor their sustainability performance.

Three suppliers mentioned that they conduct background checks of the sub-suppliers during supplier selection. One of the suppliers mentioned "We have a supplier code of conduct. We update the document every year based on the updated standards. During supplier selection process, we

ensure that the sub-suppliers have the relevant documents as proof for the sustainability requirements in the code of conduct". They mentioned that they conduct annual audits to monitor sub-supplier sustainability performance. Table 7 summarizes the methods used for implementation of direct strategy used by lower-tier suppliers to monitor their sub-supplier sustainability performance.

Table 7: Summary of lower-tier suppliers who use direct strategy to monitor their sub-supplier sustainability performance

Strategy used	Illustrative quotes and data	Method of implementation	Respondents
Direct	Team in place who are actively involved in inspecting the sites of their sub-suppliers, interact with the team responsible for reporting of sustainability data	Conduct *quarterly audits* to check all the sustainability related documents	3 (S4, S25, S30)
Direct	Submitting annual audit report to the sub-supplier to create awareness about the required sustainability standards	Conducting *bi-annual audits* of sub-suppliers	2 (S21, S24)
Direct	Conducting background check during supplier selection process.	*Annual audits*	3 (S14, S17, S27)

4.2.2.2 Indirect

Four of the 12 suppliers who answered that they monitor sub-supplier sustainability performance mentioned that they are not directly involved in monitoring the sustainability performance of their sub-suppliers. This strategy involves the immediate supplier who will be vested with the responsibility of monitoring the sustainability performance of the sub-supplier. The sustainability requirements will be communicated to the immediate supplier who will provide an assessment report of the sub-supplier sustainability performance.

One of the three suppliers mentioned "The sub-supplier is also a supplier located far below. We communicate the requirements to our immediate supplier. Our immediate supplier is responsible to provide sustainability related data of the sub-supplier". The suppliers mentioned that the sustainability requirements are communicated to the immediate supplier. The immediate supplier is responsible to collect the required data and pass it on to the lower-tier supplier. The other two suppliers along with this supplier also mentioned that they use the same strategy for monitoring their sub-supplier sustainability performance. All the three suppliers mentioned that they demand bi-annual audit reports from the immediate supplier to monitor the performance of the sub-suppliers.

The other remaining supplier out of the four mentioned that they are part of a community from where they access data related to sustainability. They mentioned that it was a portal where suppliers of material to the same domain are data about their sustainability performance. The supplier mentioned "Since we are not directly engaged, we can save money and resources. It also helps is monitor the sustainability of our sub-suppliers". The supplier mentioned that the sub-suppliers upload documents providing proof of their performance once in a year.

Table 8 summarizes the methods used for implementation of indirect strategy used by lower-tier suppliers to monitor their sub-supplier sustainability performance.

Table 8: Summary of lower-tier suppliers who use indirect strategy to monitor their sub-supplier sustainability performance

Strategy used	Illustrative quotes and data	Method of implementation	Respondents
Indirect	Using immediate supplier to monitor sub-supplier performance	Conducting *bi-annual audits*	3 (S9, S15, S29)
Indirect	Using a platform where sub-suppliers upload sustainability related information	Conducting annual audits	1 (S11)

5. Discussion

This chapter will address all important appropriate themes presented in chapter 4. Empirical findings from chapter 4 will be discussed along with theoretical framework to construct suggestions. Initially, the barriers for sustainability implementation are discussed followed by the strategies adopted for sustainability implementation. Further, the barriers for monitoring sustainability performance are discussed. Lastly, the strategies used by lower-tier suppliers to monitor the sustainability performance of their sub-suppliers are discussed in detail.

The discussion is divided into two sections, each section addressing the appropriate research questions. The discussion includes existing relevant theoretical literature, and the findings are compared with this literature to identify any differences and develop the discussion. The empirical findings from the previous chapter are compared and discussed in this chapter to provide additional value to the existing literature on barriers and current strategies.

5.1 Implementation of sustainability

This section will first provide discussion about the barriers for sustainability implementation amongst lower-tier suppliers. Existing literature on barriers will be discussed and compared along with the findings in this thesis study. This will complement the existing literature and also point out if there are any differences. Lastly, the discussion will be on the strategies implemented by lower-tier suppliers for sustainability implementation.

5.1.1 Barriers for sustainability implementation

Various papers on barriers for sustainability implementation like Villena and Gioia (2020); Rauer and Kaufmann (2015) and Sajjad et al. (2015) have discussed that the main barriers faced by SMEs are lack of knowledge and resources. Papers focusing specifically on decarbonization barriers in the IT-services sector by Zhang et. al. (2022) and Burchard et. al (2021) have discussed that external barriers relating to lack of awareness and lack of resources are the main barriers for decarbonization of supply chains in the IT-services and consulting sector. But the empirical findings of this thesis study have shown that the cost as internal barrier has overshadowed the external barriers.

Cost is clearly the main *internal barrier* for lower-tier suppliers to take up sustainable practices. 83% of the suppliers have cited that cost is the main barrier. This justifies the findings in the paper by Odeh and Smallwood (2012) where they discuss that one of the main barriers for implementation of SSCM in lower-tier suppliers is high cost. Odeh and Smallwood (2012) state that one of the main barriers for implementation of SSCM in lower-tier suppliers is the high *cost* of developing environmental management systems (EMS). Adding to the existing findings on high cost of EMS implementation, one of the lower-tier suppliers mentioned "The capital required upfront for establishing EMS is extremely high. Even though this initial investment is arranged using some help, to sustain this model more capital is required to train the staff constantly based on changing requirements. As SMEs it is extremely difficult to allocate capital to EMS implementation. It can be implemented effectively only if the buyer is willing to support the capital requirement". Rauer and Kaufmann (2015) have found uneconomical recycling methods and uneconomical re-use structures in place are other factors contributing to cost being a barrier. To add to the findings of their paper, in this thesis study, interviewee 5 mentioned "We are suppliers of cutlery and cups, and the main mode of sustainability implementation is through implementation of recycling both in the product as well as packaging. The current recycling technologies are not cost efficient. The recycling rates are very high and implementation of recycling in all our operations will result in a significant increase in the overall cost of the product". Granoff et.al. (2016) also lists cost as one of the various barriers that affect an organization to invest in low carbon infrastructure. Other papers like Min & Galle, Hines & Johns and Farahani, Asgari, & Davarzani have explored the same result of high cost for low carbon technology being the main barrier for implementation of SSCM amongst lower-tier suppliers in the supply chain network (Odeh and Smallwood, 2012). Shao Hung Goh in his paper on the barriers for low carbon investments also concludes that cost is one of the main barriers for low carbon investments. The findings from this study on high cost of low carbon technology complements the existing literature. Interviewee 4 quoted "Sustainability is becoming a new requirement more than just a trend. We are currently trying to be more sustainable in our operations. But the main barrier is the high cost of investment for low carbon technology. We are okay investing more money if we are getting better returns. But the clients are not willing to increase the cost and pay more. There must be better incentives for overcoming cost to drive us for complete implementation of low carbon technology". Naabi et.al. (2013) discuss that cost is a significant barrier for implementation of

SSCM in LTSM. They identify a list of barriers in their paper. High cost of sustainability management systems, high cost of waste disposal, uneconomical recycling and high cost of environmentally friendly packaging are amongst the main barriers that they identify for SSCM. Narisima et.al. (2019) discuss that in their paper of drivers and barriers to SSCM implementation that one of the main barriers for SSCM implementation is the high cost of sustainability implementation in the supply chain. Sajjad et. al. (2015) in their paper about motivators and barriers for SSCM implementation discuss that one of the main organizational barriers for SSCM implementation is the high cost. They discuss that suppliers are charged a premium and their lack of knowledge is used as an advantage resulting in exploitation and high cost. Abbasi & Nilsson (2012) in their paper on making supply chains more environmentally sustainable identify cost as an extensive barrier for SSCM. They discuss that incorporating environmental aspect during purchasing will result in higher costs for suppliers. They further discuss that the suppliers find that the cost to adhere to variety of environmental compliance standards motivate the reason for cost being a major barrier. Zhu and Geng (2010) in their paper on barriers for emission reduction discuss that high cost for eco designs, high cost for disposal of waste and expensive environmentally friendly packaging are the amongst the main barriers for greening of the supply chain. Movahedipour et.al. (2017) in their paper on barrier analysis for implementing SSCM identify four barriers related to cost. They discuss that the high cost for recycling of environmentally friendly packaging, green product designs and high costs for environmental systems are amongst the main barriers for implementation of SSCM. Like the literature described above, suppliers respond that the investment cost for environmentally sustainable systems was high. Oberthur et.al., (2020) discuss that the high investment costs for low carbon technology prove to be a barrier for SMEs to uptake low-carbon technologies. Kazancoglu et.al., (2020) in their paper on barriers for circular supply chains discuss that high cost of procuring raw material for recycling and the uneconomical recycling rates prove to be a barrier for SMEs. This study also identifies the above reasons explored as the main reasons for cost being the main internal barrier.

Villena and Gioia (2020) state that lower-tier suppliers are mostly affected by *external barriers*. They discuss that lower-tier suppliers often do not have knowledge about sustainability. Even if they do have an understanding, they are SME's and are usually located in countries where the regulations are not strict. Interviewee 2 also mentioned that the difference in regulations and requirements between Asia and Europe affected them the most in terms of regulations. Interviewee

2 mentioned “We do not have the required knowledge about the sustainability requirements of the company. We are just following the word of mouth about sustainability implementation and do not have the actual knowledge about areas that require sustainability implementation. The difference in regulations and requirements between Asia and Europe has affected us the most. We are currently meeting all the requirements in the country we are located. But our client located in Europe wants us to get additional certifications that are according to the environmental policy followed in Europe. These certifications will cost us a lot of money and resources”. Rauer and Kaufmann (2015) have discussed in their findings that environmental standards-related barriers arise due to the absence of understanding of a generalized sustainability target like carbon dioxide emission standard. This is due to the fact of different environmental regulations in different countries (Rauer and Kaufmann, 2015). Papers like Odeh and Smallwood (2012), Min and Galle (1997) and Farahani, Asgari, & Davarzani have also identified lack of awareness and lack of expertise as one of the main barriers for SSCM implementation amongst lower-tier suppliers. Movahedipour et.al. (2017) in their paper on barrier analysis for implementing SSCM identify lack of clear information about sustainability and lack of facility for implementation as the barriers for implementation of SSCM. Zhu and Geng (2010) in their paper on barriers for emission reduction discuss that lack of capability to solve sustainability issues internally and lack of expertise on environmental issues as the barriers for greening the supply chain. Tay et.al. (2015) in their paper on review on drivers and barriers towards sustainable supply chain practices discuss that the firm size has a huge impact and influence the implementation of SSCM. They discuss that larger firms are most likely to engage in SSCM and SME’s show less involvement due to the size of the firms and also the willingness to participate because of engagement with focal company. They identify that lack of people, lack of understanding to integrate sustainability in operations and lack of training of staff in sustainability matters are some of the important barriers in SMEs to implementation of sustainability. In a paper on barriers for EMS implementation by Schmidt and Osebold (2014), the main barriers identified are lack of knowledge about the sustainability standards, lack of expertise and lack of governmental pressure. Zhang et.al., (2022) also discuss that the main barrier for decarbonization in SMEs is due to the lack of awareness and lack of support from supply chain partners. In their paper on barriers for decarbonization they discuss that lack of awareness is a significant barrier. Naabi et.al. (2013) in their paper on interaction between barriers for SSCM implementation identify that lack of clarity regarding sustainability, lack of

evaluation measures about sustainability and lack of training and education about sustainability as the main barriers for SSCM implementation. The findings in this thesis study also add to the existing literature. The suppliers mentioned that they do not have the *knowledge to conduct audits* by themselves. Interviewee 2 mentioned that the main resource barrier was "We do not have the required knowledge about the sustainability requirements. Even if we understand the requirements, it is very difficult to train people in the organization to conduct audits". Chkanikova and Mont (2012) in their paper on drivers and barriers in corporate supply chain responsibility discuss about regulatory and resource barriers. They discuss that difference in regulations and sustainability policies in different countries puts suppliers in dilemma and often prove to be annoying to follow different norms. They discuss that the lack of harmony in sustainability regulations are a major barrier. Further, they discuss that lack of resources internally to implement SSCM and lack of knowledge and expertise to further develop SSCM in chain is another barrier. Ravi and Menon (2021) discuss that the lack of training/human expertise on sustainability is a major barrier for SSCM implementation. Interviewee 2 also mentioned that the main resource barrier was "We do not have the required knowledge about the sustainability requirements to train people in the organization to conduct audits". The results obtained from the responses to the questionnaire in this study also identifies different regulation in different countries and less strict regulations in countries, lack of knowledge and resources to be the main external barriers affecting the implementation of sustainability amongst lower-tier suppliers.

5.1.2 Strategies for sustainability implementation

Villena and Gioia, (2020) discuss that the lower-tier suppliers often lie outside the visibility horizon and hence they do not attract the attention from any of the stakeholders or the media. Because of the lack of attention, the lower-tier suppliers do not feel pressurized to take up sustainable practices. Nath et.al. (2019) have discussed that one of the main barriers for implantation of sustainability in the lower tiers of the supply chain is the lack of consistency of standards and transparency. They mention that the sustainability measures implemented is different in different tiers and that is due to the size and resources available. Even in this thesis study, we can see that the lower-tier suppliers have adopted various strategies for implementation of sustainability. The selection of strategy is based on their requirement and cost effectiveness.

Fedrezzi and Rogers (2002) in their paper on energy efficiency strategies have discussed that switching to 100% LED lighting and installation of sensors for automated lighting is a strategy that results in significant energy savings. Papers like O'Keeffe et. al (2016) and Kolokotroni et.al., (2015) have all discussed and summarized that utilization of LED lighting, improved insulation by using automated HVAC solutions and implementation of smart sensors that help control the ambient lighting and temperature indoors results in achieving high energy savings leading to improved energy efficiency. More than 70% of the lower-tier suppliers have implemented the transitioning to 100% LED lighting and workplace insulation strategy. They mentioned that it was one of the most cost efficient yet effective measure for achieving carbon neutrality.

Hu et.al., (2021); Khan et.al., (2021); Song et.al., (2021) and Wu et.al., (2021) have all identified different sources of renewable energy sources to substitute for the fossil fuel energy sources. All the papers have identified that majority of the energy demands in the respective domains can be met by renewable energy sources and the transition to renewable energy sources will result in a noticeable amount of decrease in carbon emissions. Millot and Maizi, (2021) point out a very critical finding that transitioning to renewable energy has not only resulted in carbon dioxide emission reduction but has also resulted in the reduction of other toxic and harmful GHG's like nitrogen dioxide and methane. The findings from this thesis study also add to the existing literature as the lower-tier suppliers mentioned that they had made a partial transition to using renewable energy and this has helped them achieve a reduction in their carbon emissions as it was more carbon intensive to burn fossil fuels to generate electricity. However, they mentioned that the main barrier to transition to complete renewable energy is because of high prices of renewable energy.

Papers like. Zhang et.al., (2022), Wu et.al., (2021) and Prussi et.al., (2019) have discussed that electrification of transport will help reduce the carbon emissions and accelerate the transition towards carbon neutrality. They discuss that although there are papers on usage of alternate fuels, electricity has proven to be the most practical alternative and since electricity can be produced by renewable energy sources, this will result in deep decarbonization of the transport sector. The lower-tier suppliers mentioned that they have electrified their fleet for transportation, and this has helped reduce their cost and also resulted in achieving reduction in emissions.

Nizetic et.al., (2019) and Vertakova et.al., (2019) have discussed in detail that waste management strategies for proper waste disposal results in huge amount of energy savings. They discuss that the energy savings can be achieved by eliminating the waste at the EOL. They discuss this can be achieved by using materials that can reused or recycled. They also mention that during the manufacturing and material selection process, the disposal strategy and the energy required for disposal have to considered. These strategies can be drafted in a policy to be implemented which will help reduce emissions. They discuss the importance of EOL policy and its implications to help achieving reduction in carbon emissions. The lower-tier suppliers have implemented an *EOL policy*. All the suppliers have mentioned that their EOL treatment policy includes ISO 14001, ROHS and REACH compliance standards. This consideration helps in achieving carbon emission reduction. While discussing the material selection, both the papers identify that packaging material is a significant contributor to emissions related to waste disposal. They identify that using environmentally friendly packaging can help reduce waste accumulation and increase recycling opportunities that help in carbon emission reduction. The thesis study further adds to this literature as the results showed that the lower-tier suppliers use environmentally friendly material for packaging, and this has resulted in energy savings related to EOL and waste disposal. Also, various strategies of recycling and reuse has been a key strategy of sustainability implementation amongst lower-tier suppliers.

5.2 Monitoring sub-supplier sustainability

This section will first provide discussion about the barriers faced by lower-tier suppliers for monitoring sustainability performance of their sub-suppliers. Lastly, the discussion will be on the strategies adopted by lower-tier suppliers to monitor the sustainability performance of their sub-suppliers. Existing literature on strategies will be discussed and compared along with the findings in this thesis study. This will complement and add to the existing literature on lower-tier supply chain management (LTSM).

5.2.1 Barriers for monitoring sub-supplier sustainability performance

Villena and Gioia (2020) discuss that there is an increased pressure on all the actors in the supply chain to take up sustainability. They discuss that most of the environmental burden occurs in the lower-tiers of a supply chain as more than 70% of the lower-tier suppliers are not monitoring the

sustainability performance of their sub-suppliers. Their study revealed that only 10-15% of companies require their sub-suppliers to comply with sustainability standards. The findings of the study complement the existing literature and finds that more than 60% of the lower-tier suppliers do not have sustainability as a criterion for choosing their sub-suppliers.

Grimm et al., (2014) discuss that current regulations like REACH and the development of standard frameworks like SBTi demand sustainability-information from their lower-tiers of the supply chain. Rauer and Kaufmann (2015) discuss that the enforcement amongst lower-tier suppliers is a main challenge as the lower-tier suppliers lack resources and expertise to monitor their sub-supplier sustainability performance. Schmidt and Osebold, (2014) discuss in detail in their paper on barriers for supplier sustainability performance assessments that the main barriers for monitoring sub-supplier sustainability performance are lack of knowledge about the sustainability standards, lack of expertise and lack of governmental pressure. The discussion mentions that suppliers often have no knowledge about the sustainability standards and requirements. SMEs are located higher upstream in the supply chain and hence lack access to knowledge about these requirements. This thesis study adds to the existing literature as the findings reveal that the main reason for suppliers not monitoring their sub-supplier sustainability performance was the lack of resources and expertise.

5.2.2 Strategies used for monitoring sub-supplier sustainability

Willhelm et.al. (2016) mention that buying firms are paying attention to stakeholders emphasizing the buying firm's responsibility in managing supplier sustainability upstream in the supply chain. They identify four different characteristics that suppliers can follow to manage their sub-supplier sustainability performance. The characteristics were open, closed, third party and don't bother. Their paper complements the research conducted by Tachizawa and Wong (2014) where they discuss in their paper on multi-tier supply chains four basic approaches taken by organizations: direct, indirect, work with third parties and don't bother. In the direct approach, the focal company has direct access to lower-tier suppliers and hence the company can easily interact with the lower-tier suppliers and to govern and monitor their environmental sustainability performance. In the indirect approach, the lower-tier suppliers will be directly monitored by the first-tier suppliers. The focal company will allocate the responsibility of governance and monitoring of the lower-tier

suppliers to the first-tier supplier. In the Third-party approach, the focal company will collaborate with another centralized firm which manages the monitoring of suppliers for firms in the same industry and these firms might also use third-party databases to monitor the sustainability of the suppliers. The Don't bother approach is where firms focus only on the first-tier suppliers and have less intention to influence them to adhere to or follow sustainability standards.

The results of the study by Tachizawa and Wong (2014) showed that most of the monitoring of the sub-suppliers is assigned to the first-tier suppliers (Indirect approach). They mention that this approach reduces information asymmetry and transactional costs. The result from this study adds to this literature as few suppliers in this study also have adopted the indirect strategy for monitoring the sustainability performance of their sub-suppliers. One of the suppliers mentioned "Since we are not directly engaged, we can save money and resources. It also helps is monitor the sustainability of our sub-suppliers". Lee (2010) discusses that the main advantage of adopting the direct strategy over the indirect strategy is that the focal business has direct engagement and authority over their sub-suppliers. But the main reason for the results in the study by Tachizawa and Wong (2014) showing the dominance of the use of indirect approach was due to the requirement of additional capital and resources that are linked to the direct approach. On the contrary, this thesis study finds a different approach taken by lower-tier suppliers to monitor the sustainability performance of their sub-suppliers.

Majority of the lower-tier suppliers in this study use the direct strategy discussed by Tachizawa and Wong (2014). They mention that the direct strategy involves the direct engagement of the focal business with their sub-suppliers. The findings from this study adds to the literature. Interviewee 5 mentioned "We have a team that is responsible for reporting of sustainability data. The team conduct regular checks of all the sustainability related documents". Interviewee 5 further mentioned "In order to enforce sustainability amongst our sub-suppliers we conduct quarterly audits". The authors also discuss the role of the company in this direct strategy approach as links developed on ad hoc basis. The finding from one of the lower-tier suppliers who is part of this thesis study who mentioned "We update the sustainability requirements and provide our annual report of our sustainability performance to the sub-suppliers. This helps them understand the requirements and the scale of implementation that we expect from them" adds to the existing literature that lower-tier suppliers also use this method of implementation in the direct strategy.

As Lee (2010) discusses in the paper that the challenge with the direct strategy is that it is capital and resource intensive, on the contrary the lower-tier suppliers find this approach to be more suitable for the sector they belong as most of the lower-tier suppliers have adopted the direct strategy. This adds to the findings discussed in the paper by Lee (2010) that there are some exceptions where the suppliers value their long-term relationship, and this value helps them to secure a low-cost strategy with the existing supplier. Willhelm et.al., (2016) discuss that the suppliers favor the direct strategy when the sub-suppliers are located in the same geographic region and since lower-tier suppliers are SMEs, they can save import duty and transportation costs. This enables them to adopt the direct strategy. Table 9 summarizes the strategies and approaches adopted by lower-tier suppliers.

Table 9: Summary of strategies implemented by lower-tier suppliers for monitoring sub-supplier sustainability performance

Strategy	Illustrative quotes	Methods of implementation
Direct	• Team in place who are actively involved in inspecting the sites of their sub-suppliers • Submitting annual audit report to the sub-supplier to create awareness about the required sustainability standards • Background check of the sub-supplier during the process of selecting the sub-supplier	• Conduct *quarterly audits* to check all the sustainability related documents • Conducting *bi-annual audits* of sub-suppliers • *Annual audits*
Indirect	• Using immediate supplier to monitor sub-supplier performance • Using a platform where sub-suppliers upload sustainability related information	• Conducting *bi-annual audits* • *Annual audits*

6. Conclusion

This final chapter will present the concluding answers to the research questions. Each research question will be answered individually. The answer to each research question will begin with a brief description of the importance of the answer to the question followed by concluding answer to the specific question and end with recommendations. Lastly, it will suggest the implications established from the findings and scope for future research on the topic.

6.1 Research questions

RQ1. What are the barriers faced by lower-tier suppliers for implementing environmental sustainability in their operations?

Several barriers that were faced by lower-tier suppliers located upstream in the supply were identified for implementation of environmental sustainability measures. The result from this study provides valuable knowledge to the case company to develop actions to help their lower-tier suppliers overcome the identified barriers.

The empirical findings of this thesis study have shown that the cost as an internal barrier has overshadowed the external barriers. Cost is clearly the main internal barrier for lower-tier suppliers located upstream in the supply chain to take up sustainable practices. 83% of the lower-tier suppliers have cited that cost is the main barrier for implementation of sustainability measures in the organization. They mentioned that *high cost of setting up of an environmental management system (EMS)* and the *high upfront cost of investment in low carbon technology* is one of the key motivators for selecting cost as the barrier. They explained the second motivating factor for selecting cost as the barrier was due to the *high expense incurred in procuring renewable energy*. They also mentioned about *uneconomical recycling* and customers unwillingness to pay additional price for a low carbon product. They mentioned that obtaining *certificates and permits are expensive*.

The external barriers that were identified were the *lack of knowledge about sustainability requirements* amongst lower-tier suppliers. The lower-tier suppliers mentioned that even if they had awareness, the *lacked the resources in terms of trained staff* for implementation and conducting audits to stay updated with new requirements. The other main barrier was the *difference*

in regulations in different countries. The lower-tier suppliers mentioned that they are affected by strict regulations in one country and less strict regulations in the country where they are located.

Recommendations

As a suggestion to the responses, to high cost of setting up EMS, lower-tier suppliers have a misconception about high cost of setting up an EMS and green purchasing programs. EMS and green purchasing programs reduce the accountability cost for the suppliers. They help in conserving resources and result in reduced disposal and costs related to disposal (Min and Galle, 1997). Investing in EMS helps to reduce input cost in the longer run. The high cost of obtaining permits is only an initial investment cost and will not be recurring cost.

Fossil fuels are finite resources, and such resources have a trend to get depleted soon. Investing in renewable sources will reduce risk of supply due to depletion of finite sources and will create positive economic value. Fossil fuels give rise to regional conflicts as they are unevenly distributed. Due to uneven distribution and the need to import energy from fossil fuels, if the suppliers are dependent on energy from fossil fuels, there is a risk of high cost as energy prices are extremely volatile. A classic example is the current ongoing increase in energy prices in European countries that were dependent on natural gas supply from Russia that was halted due to the ongoing war in Ukraine. On the contrary, renewable resources are evenly distributed, can be harnessed locally, cost is predictable, and the cost can be forecasted.

Addressing the uneconomical recycling rates, recycled material is less expensive compared to procuring fresh raw materials. This results in a lower operating cost. Also, being involved in recycling will result in incentives and tax exemptions in some countries (Min and Galle, 1997).

RQ2. What are the strategies adopted by lower-tier suppliers to ensure implementation of environmental sustainability in their operations?

Several strategies used for implementation of environmental sustainability in various ways were identified. The results will help lower-tier suppliers to get awareness of the different methods that are available for sustainability implementation. It will give them an opportunity and also motivation to implement more sustainable measures. The empirical data provides valuable information to the case company about the awareness of sustainability amongst lower-tier suppliers by helping them understand the strategies for implementation and scale of implementation.

The lower-tier suppliers have implemented various sustainability strategies to achieve carbon emission reduction in their direct operations. Most of the suppliers are *calculating their carbon footprint* from operations. They have installed *100% LED lighting* in the workplace and have also implemented measures to achieve better *workplace insulation* and hence achieve greater energy efficiency. Many suppliers have *electrified their fleet* that is used for transportation purposes. In addition to fleet electrification, the suppliers have also transitioned to *using electricity for heating* purposes instead of using fossil fuels. The suppliers have transitioned to *using renewable energy* in the workplace. This provides an opportunity to transition to 100% renewable electricity. They have also invested in *energy efficient machinery* that uses less energy and provides an opportunity for the lower-tier suppliers to use renewable energy to run these machines. Few suppliers have implemented *reusable designs* that help in reducing energy consumption during the process.

In addition to the above strategies, the lower-tier suppliers have implemented strategies that help achieve reduction of indirect emissions. They have implemented an *EOL policy*. This policy takes into consideration the emissions related to transportation and disposal of the material or product. In connection to the EOL policy, the lower-tier suppliers have transitioned to *sustainable packaging material*. Most of the suppliers use environmentally friendly packaging. The lower-tier suppliers have implemented various *strategies for recycling and reuse*.

Recommendations

The most effective strategy for achieving quick reduction in carbon emissions is to reduce energy usage is in buildings. All lower-tier suppliers must work on their factories or manufacturing places to make them more efficient by *implementation of 100% LED lighting* and increasing efficiency of heating and cooling with better *workplace insulation*. The suppliers must transition to *complete use of renewable energy* in their electricity mix. On-site renewable energy generation is an excellent approach to carbon offsetting. Solar PV's are the most versatile form of renewable energy that can be generated on-site. Although the initial investment cost is high, the operating cost for solar PV panels are almost negligible and hence return on investment period is not long. In recent years, solar PV panels are becoming less expensive and affordable due to the subsidies offered in various countries. Land sparing technique can be used as an approach to carbon offsetting. Land sparing involves development on one part of the land and natural habitat in the remaining part. This involves afforestation where the natural habitat acts as a natural carbon sink

RQ3. What are the strategies used by lower-tier suppliers to monitor their sub-supplier sustainability performance?

Two major strategies were identified based on the results from the thesis study. The identification of these strategies will help the lower-tier suppliers compare their strategy against the strategy used by other suppliers and give them an understanding of the strategy used by other lower-tier suppliers in the same domain.

Majority of the lower-tier suppliers have adopted *direct strategy* as the main strategy for monitoring the sustainability performance of their sub-suppliers. They have used this strategy as they have direct access and contact with the lower-tier suppliers. The lower-tier suppliers have mentioned that this helps them maintain their long-term relationships with the sub-suppliers. They also mentioned that it is easier to communicate and enforce sustainability requirements as they are aware of the mode of operation of the sub-suppliers. Amongst lower-tier suppliers who have adopted the direct strategy, the methods used for implementation of direct strategy are:

1) Lower-tier suppliers *have a team in place who are actively involved in inspecting the sites of their sub-suppliers* and interact with the team responsible for reporting of sustainability data.
2) They also provide information on ad hoc basis – *submit annual audit reports* – so that the sub-suppliers have awareness about the sustainability requirements.
3) They *conduct background checks during supplier selection*.

The main tool used for monitoring performance is conducting regular audits. A variety of different schemes of audits are used by lower-tier suppliers. Some of them are: *Quarterly audits, Bi-annual audits and Annual audits*.

Apart from the direct strategy, lower-tier suppliers also use the indirect strategy to monitor the sustainability performance of their sub-suppliers. They *use the immediate supplier* to monitor the sustainability performance of their sub-suppliers. The immediate supplier is responsible for providing information regarding sustainability requirements to the sub-suppliers and responsible to provide the lower-tier supplier with the performance assessments reports regarding the sustainability of the sub-suppliers. They also use a *platform where all the sub-suppliers of material in that domain publish sustainability related data*. The main tool used for monitoring performance

is conducting regular audits. The lower-tier suppliers using the indirect approach conduct *annual* and *bi-annual audits*.

Recommendations

All lower-tier suppliers must start monitoring as current regulations like REACH in the European Union (EU) has pressurized firms to collect sustainability related information from suppliers located in all tiers of the supply chain. The lower-tier suppliers must follow a framework for monitoring their lower-tier suppliers. A suggested framework is based on the direct LTSM approach discussed by Meinlschmidt et.al. (2017). The first step for lower-tier suppliers is to conduct a heat map analysis to identify the sub-suppliers who supply environmental sensitive material and requires more focus and attention. Since all sub-suppliers do not need critical focus, the lower-tier suppliers can focus on the sub-suppliers that supply material that is prone to non-compliance and results in environmental hazards. This approach requires few resources compared to the lower-tier supplier focusing on sub-suppliers who are compliant to the required standards. To incentivize the sub-suppliers who are showing sustainability performance, the lower-tier suppliers must resort to buying more from such sub-suppliers to establish longer relationship ties. Another important approach that can be combined with the above approach is the concept of nexus supplier (Sancha et al., 2018). This nexus supplier can be located anywhere in the supply chain. The lower-tier suppliers can use the sub-suppliers with a good sustainability and supplier of any material to act as nexus supplier who provides strategic information about the performance of sub-suppliers who supply environmental sensitive material.

6.2 Scope for future research

This thesis study investigates decarbonization barriers and strategies and hence focuses only on the environmental aspect of sustainability. Hence, the results from this thesis can used as foundation for further research. This section will present suggestions for future research.

Firstly, the results obtained are primary data mainly obtained from the lower-tier suppliers of the supply chain of the case company. Although, suppliers belonging to supply chains of two other companies in the same sector were included in the studies, the results from this study cannot be considered conclusive and more research must be carried out considering suppliers from various other companies in this sector. The consideration of suppliers from supply chains of different

companies will allow validation for the findings of this thesis. This consideration could not be done in this study due to the lack of time and resources. Also, since the case company has operations in three regions and suppliers from only two regions were considered, future research can include suppliers from the third region and develop a comparison between the different regions. A thorough understanding of lower-tier supplier sustainability performance can be assessed only by considering both the environmental and social aspects. We know that sustainable supply chain management is based on the triple bottom line approach. Hence, future research should be conducted by considering both the environmental aspect and social aspect or a separate study considering the social study must be carried out by considering the same boundary conditions. Finally, this thesis study focuses only on identifying the barriers for implementation of sustainability amongst lower-tier suppliers and implementation strategies. It also focuses on the strategies used by lower-tier suppliers for monitoring of sub-supplier sustainability. Based on the identified barriers and strategies recommendations are formulated. Future study could focus on the strategies used by companies to help lower-tier suppliers overcome these barriers.

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A Appendix: Interview questions

This appendix presents the questions that were included in the questionnaire. The questions were framed before the questionnaire was circulated in the form of a Microsoft from.

- What are the sustainability measures that you are taking up as an organization?
- How are you as an organization ensuring carbon neutrality in terms of energy usage, sourcing, operations and manufacturing?
- What is the main barrier for the organization to switch to a low carbon product? Cost, resources or regulations?
- Do you have sustainability as a criterion for choosing sub-suppliers?
- How are you ensuring that your sub-suppliers are sustainable in their operations?
- Do you have an end-of-life treatment policy that is in place in your organization?
- Have you implemented processes that ensure recycling or refurbishing of products? Can you provide an example?
- What is the packaging material that you use in the organization?
- Has the company looked into or implemented any abatement technologies for carbon offset or sequestration?
- What is the customer's reaction or response to the low carbon product?
- Do you see the low carbon product gaining more market due to better understanding of sustainability among customers?
- What is the net zero ambition of the company?

B Appendix: Questionnaire

Supplier survey

Dear supplier,

I am a master's student carrying out a case study as a part of my master's thesis to ensure an emission free supply chain. You as suppliers play a major role in sustainability performance of the supply chain.

The aim of this survey is to gather information about the challenges faced by suppliers to take up environmentally sustainable practices. The answers from this survey will help to identify the challenges faced by you as a supplier. It will help to achieve the goal of this thesis study by helping me formulate suggestions based on discussions of available technologies, processes or materials in order to improve your environmental sustainability performance.

All the responses will be recorded anonymously.

1. Select your region *

- ◯ Europe
- ◯ Asia

2. Please select to which domain your product belongs to *

- ◯ Hardware
- ◯ Software
- ◯ Packaging
- ◯ Fleet supplier
- ◯ Building materials
- ◯ Building equipment
- ◯ Energy supplier
- ◯ Furniture
- ◯ Consumer goods

3. Mention the product you supply *

Enter your answer

4. What are the sustainability measures that you are taking up as an organization? *

Enter your answer

5. How are you as an organization ensuring carbon neutrality in terms of energy usage, sourcing, operations and manufacturing? *

Enter your answer

6. What is the main barrier for the organization to switch to a low carbon product? *

- [ ] Cost
- [ ] Resources
- [ ] Regulations

7. What is the motivation for selection of barrier in the above question? *

Enter your answer

8. Do you have sustainability as a criterion for choosing sub-suppliers? *

- ◯ Yes
- ◯ No

9. How are you ensuring that your sub-suppliers are sustainable in their operations? Kindly elaborate on the strategy used *

Enter your answer

10. Do you have an end-of-life treatment policy that is in place in your organization? *

- ◯ Yes
- ◯ No

11. Does the end-of-life treatment policy include ROHS, WEEE and ISO compliance? *

- ◯ Yes
- ◯ No

12. Do you see recycling and refurbishing of products as an emerging trend to induce circularity of materials and energy to achieve sustainability? *

Enter your answer

13. Have you implemented processes that ensure recycling or refurbishing of products in accordance with the policy in place? Can you provide an example. *

Enter your answer

14. What is the material that is used for packaging of your product? Can you mention the reason for using this packaging material. *

Enter your answer

15. Has the company looked into or implemented any abatement technologies for carbon offset or sequestration? *

Enter your answer

16. What is the customer's reaction to the low carbon product? *

Enter your answer

17. What is the net zero ambition of the company? *

Enter your answer