

Climate Change Impacts and Sustainable Supply Management in the Natural Latex Mattress Industry: A Case Study of a Sri Lankan Export Manufacturer

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DOI: <https://doi.org/10.51583/IJLTEMAS.2026.151000009>

Received: 30 September 2026; Accepted: 05 October 2026; Published: 29 October 2026

ABSTRACT

In particular, since they are extremely sensitive to higher temperatures, unpredictable rainfall and changing seasons. The present study sample is a Sri Lankan organic latex foam mattress manufacturer which exports to the United States and considers climate change impacts as a systematic shock while supply management challenges as competitive challenge. Climate change is also fully integrated into long-term value creation and integrated into competitiveness in sustainable business planning of the natural rubber industry. We reported the aim assessed in this paper to understand the need for climate-induced disruption in supply management (the factors disallowing organizations to achieve effective supplies for a healthy thin-supply-chain) and announced how we can solve these problems for sustaining a climate-resilient supply chain. Research Design — A qualitative case study design has been implemented. In order to have the data required for analysis, primary and secondary data are collected from seven semi-structured interviews conducted with management, production workers and rubber suppliers sampled random according to the accessibility convenience sampling, secondary by previous studies, the company's website and industry papers. Data were analysed through thematic analysis. Overall, the figures show that while climate-dependent companies rely heavily on climate circumstances and encounters serious issues in terms of material supply, production technology and labour productivity. Rainfall and drought influence the quality and quantity of latex, while methods used by manufacturers such as Dunlop restrict the amount of production that can be achieved and how dense it is to be formed into foam; poor working conditions, low levels of training and labour shortages limit productivity. The climate change debacle does not present a new entrance risk-profile the research again finds that climate change exacerbates legacy operational risks. Also recommended are diversifying the GOLS-certified supply base, implementing climate-smart practices and monitoring, transitioning to air micro-bubbling technology for washing organic guidelines fibres along with R&D investments and opportunities to enhance working conditions & training. This research contributes to the sustainable supply chain management literature by illustrating the use of climate-change risk information in strategic business planning and anticipatory adaptation actions in established agricultural manufacturing firms, but also presents several implications for practice regarding how international production can be organized while achieving goals for sustainable development through exports.

Keywords: supply management, climate change adaptation, natural latex foam, sustainable supply chain, labour productivity

INTRODUCTION

Background of Study

Climate change is increasingly being recognized as a major disruptor of global agricultural supply chains, with the natural rubber sector being one of the most vulnerable industries. Increasing temperatures, changing rainfall patterns, and the increased occurrence of extreme weather events directly impact the growth of rubber trees, the production of latex, and the reliability of raw material supply in terms of logistics (Pinizzotto et al., n.d.; S. et al., 2021). It is critical for enterprises that rely on climate sensitive agricultural inputs to integrate climate change into business strategy for continued value generation. The United States is one of the key mattress markets worldwide. The U.S. has a high consumer demand for mattresses because of favorable economic conditions, large population base and desire for comfort and quality in the country. American consumers are increasingly seeking premium mattresses that provide superior comfort, support and durability. With the increasing awareness of the environment, more and more people are choosing eco-friendly and sustainable mattress options such as natural latex materials (Hewer, 1953).

Sri Lanka is a key player in the global rubber business today and is known for producing high quality rubber. The country has the most favorable conditions for the growth of rubber trees. Abundant precipitation and temperate conditions favor superior quality latex. To ensure that the latex produced in Sri Lanka meets the relevant international standards, sustainable methods of production and stringent quality control measures have been implemented. The mattresses made from natural latex in Sri Lanka are famous for their quality, comfort and durability.

The management of the export supply of natural latex mattresses must understand the general environment of the business and the difficulties of suppliers and manufacturers. A major problem is that the suppliers are having a hard time keeping up with the growing demand for natural latex mattresses. The production of natural latex mattresses requires an uninterrupted flow of latex from rubber trees (Koch & Raulf-Heimsoth, 2004). A number of factors can restrict the availability of raw materials, such as poor cultivation of rubber trees, unfavourable weather conditions and disease outbreaks, which can result in a substantial reduction in the quantity of natural latex.

The demand for natural latex mattresses may not have been met due to production capacity constraints even if there was availability of raw materials. The process of manufacturing natural latex mattresses involves various technical procedures including latex extraction, foam formulation, and mattress construction (Ramli et al., 2022). A supply shortage can happen if they have bad production methods or manufacturing facilities that can't handle the increased demand. The limitation of resources, old machines and scarcity of workers are the reasons behind the reduction of manufacturing capacity (Ramli et al., 2021).

This research focuses on a born-global company producing organic mattress foam from natural rubber. The U.S. is the primary market for mattresses, and it sources superior natural rubber from local suppliers. Natural latex is the company's primary raw material and is sourced from farmers with Global Organic Latex Standard (GOLS) certifications, which means its mattresses are organic. Today, the company uses Dunlop technology to convert natural latex into latex foam.

Problem Statement

For any manufacturing organization, the availability of resources and the efficiency of the production process are vital for the organization to maximize its production. Supply management is an integral part of the supply chain management. It is important to improve efficiency and reduce costs, especially in the case of manufacturing enterprises. Supply management problems exist for natural latex foam manufacturers because of several issues. Natural rubber shortage is a common problem in the latex foam manufacturing industry (Sriyalatha, 2018). The rubber sector in Sri Lanka is not capable of producing rubber in quantities sufficient to meet the increasing domestic and foreign demand at present.

The company we looked at is in big demand for natural organic latex mattresses and has a large share of the U.S. market for latex mattresses. But the company has had a hard time getting enough raw material to keep up with demand in the United States. Market research reveals that the global natural latex mattress demand was USD 34 billion in 2021, and it is projected to grow to USD 49.2 billion by 2027 with a compound annual growth rate of 6.3% (Richard Pieris & Company PLC, 2018). Natural rubber production in Sri Lanka has been declining steadily since 2011 and reached 82,000 metric tons in 2018, although local demand for natural rubber in the same year was 135,000 metric tons. This deficit of about 68,000 MT (Boundreau, 2017) greatly affects the company's ability to increase production. These restrictions underscore the need to identify barriers to supply management and to provide viable alternatives.

Research Questions and Objectives

This research addresses the following two research questions: (1) What are the factors hindering the supply management of the studied company? (2) How can the studied company find the best supply management solutions to meet export demand?

Accordingly, the objectives of this study are: (1) to identify the factors hindering supply management of the studied company; and (2) to recommend possible supply management solutions to meet export demand.

Significance of the Study

This study is a relevant contribution to the increasing discussion on the integration of climate change into sustainable business decisions and value creation, the main theme of ICBI 2026. The study demonstrates how supply management problems become actual operational risks for export-oriented industries due to environmental disruptions in the context of climate change adaptation. It explores material supply constraints arising from climate change, manufacturing technology and labor productivity barriers, and suggests adaptation measures to merge business continuity and sustainability objectives. The primary beneficiaries are the management of the company under study. However, the findings have wider implications for policymakers, industry association and supply chain managers in the organic latex mattress industry and agricultural manufacturing industry in Sri Lanka and similar economies. This study contributes to the limited empirical literature on climate resilient supply chain management in the natural rubber sector.

LITERATURE REVIEW

Material Supply

Material supply is to procure raw materials for manufacturing, and it is the first link of the supply chain. Size of plantation is an important factor in rubber yield. Smaller plantations may have increased productivity and the renewal of plantings may improve production (Pinizzotto et al., n.d.; Errington, 1995). The soil composition affects the productivity of agricultural practices and adverse soil conditions reduce the yield of rubber.

Availability of financial facilities is another factor that influences on material quantity. Rubber cultivators have to bear huge costs for felling old trees, preparing the land and replanting rubber trees when the trees reach the end of their productive life of about 10 years. The lack of credit provisions by government and financial institutions restricts the improvement of agricultural productivity in small plantations (Ugochukwu Ibe Winner, n.d.). Climate changes greatly affect rubber yield. Rubber production is optimized in areas with annual temperatures of between 25 and 28 degrees Celsius and with annual rainfall of > 1,500 mm (Pinizzotto et al., n.d.). Heavy rain hampers harvesting, but high humidity in the atmosphere favours latex exudation. In summer, young rubber plants may die in high temperature. Irregular and erratic precipitation also makes tapping difficult and decreases the yield (S. et al., 2021). Diseases and pests reduce rubber production, whereas intercropping in rubber plantations enhances soil quality and productivity (Kamruzzaman & Takeya, 2008; Giroh et al., 2020).

Production Technology

'Latex foam' means cellular rubber made from liquid latex (Sirikulchaikij et al., 2020). The two main methods used to produce natural rubber latex foam are the Dunlop and Talalay procedures (Jitkokkrud et al., 2023). The Dunlop process is the main method of manufacture of natural rubber latex foam. A Hobart Mixture is then used, in which raw rubber and chemicals are rapidly mixed together. The Dunlop method is known worldwide for its simplicity, reliability, cost-effectiveness and energy efficiency (Phomrak et al., 2020).

The Talalay method is a sophisticated method that uses vacuum and freezing processes to produce a uniform cell structure and pore size distribution of the natural rubber latex foam, resulting in softer foams with improved flexibility (Sirikulchaikij et al., 2020). The Talalay method requires considerable financial investment in equipment (Frisch, 1981).

Alternatively, the air micro-bubbling technique yields natural rubber latex foams with a cellular architecture similar to Talalay foams and it does not require vacuum or freezing equipment. The air micro-bubbling method shows an increase up to 60% compared to the Dunlop method and can be a feasible alternative (Raveshtian et al., 2022).

Labor Productivity

Labor productivity is an important performance indicator for the assessment of the efficiency of labor in the production of rubber products. Better labor productivity means a company can produce the same products using less hours of labor or more products with the same number of workers which reduces costs and increases competitiveness (Datta et al., 2005).

The labor productivity in production of rubber goods depends on a number of factors. Use of outdated equipment and technological limitations result in lower output rates and longer downtimes. Poor skills and staff training programs negatively affect the productivity of employees (Delmas & Pekovic, 2013).

Delays due to sub-optimized production procedures and workflows. Collaborative supplier relationships and open communication between manufacturers and suppliers can lead to better demand forecasting accuracy and production consistency (Sinkkonen, 2005; Kumar & Routroy, 2017).

RESEARCH METHODOLOGY

Research Design

The processes of natural rubber extraction, rubber milk production and latex mattress manufacturing were understood using qualitative research methodology. Qualitative research collection of the experience, attitude and behavior of the participants which helps to understand the individuals from their point of view and the real context. Qualitative methodology emphasizes subjectivity and context dependency of findings.

The main study methodology was data collection through semi-structured interviews. The owners of small natural rubber enterprises, owners of rubber plantations and the management and staff of companies were interviewed. The case study method was adopted to identify possible solutions to similar problems under similar conditions based on prior research.

Conceptual Framework

The conceptual framework identifies material supply, production technology, and labor productivity as independent variables, with the production of organic latex foams as the dependent variable. These independent variables determine the production capacity of the firm which in turn decides the volume available for export supplies.

Data Collection

Utilizing semi-structured interviews as the data collection method. Semi-structured interviews offer a mixture of pre-prepared questions and the room for flexibility, allowing another area or nuance to be explored that no one has suspected before. Based on previous studies, an interview guide was created. Face-to-face and audio interviews with semi-structured questions were conducted for the collection of primary data. Secondary data were obtained from previous studies, the company website and industry-related documents.

Sampling Technique

Respondents were selected through a non-probability convenience sampling practice where individuals engaged in production and indication of accessibility. The respondents were grouped into 3: company management, production employees and natural rubber suppliers. Data was collected until the saturation point. In total, seven semi-structured interviews were performed: two management representatives, three production employees and two rubber suppliers.

Data Analysis

The data were analysed using thematic analysis. Thus, we followed the method of data familiarization, iterative coding for initial codes to be generated, developing and refining a topic into a story. Thematic analysis lends itself to investigate a variety of complex phenomena and conduct in-depth qualitative data analysis (Lochmiller, 2021).

Ethical Considerations

All participants provided informed consent. The aims of the study were fully communicated, participation was voluntary, and confidentiality has been maintained. It was made clear that participants could withdraw from the study at any time without consequence. We developed semi-structured interview questions that did not bias or lead participants, and piloted them for relevance and clarity.

RESULTS AND DISCUSSION

Hindering Factors in Material Supply

The supply of material is the single most impacted element in supply management. Access to quality raw materials is essential for any manufacturing company in a timely manner.

Regulatory Compliance and Standards: The Company has developed robust processes to ensure that its organic rubber is produced in accordance with the highest standards. And suppliers are required to have a GOLS certification to make sure organic latex is not polluted with water, fertilizer or chemicals.

A supplier noted: *"Quality control of our organic rubber is one of our utmost priorities. This is one of the strictest practices we use to ensure top quality when producing your decorations. (Supplier #1)"*

Sri Lanka has very few producers of organic latex that hold GOLS certification, limiting the number of potential suppliers.

Climate Dependable With ovate latex generation, climate reliance influences a lot in yielding. Suppliers noted:

"Latex can freeze if the water mixes with the rubber eggs in rainy seasons, and latex has a low density, which is very small during drought. (Supplier #1)"

"So rain and drought are our core threats. We have rainwater that can run into the latex; these two affect our productivity. Drought seasons, on the other hand, cause a lower density of latex. (Supplier #2)"

Resilience in the face of climate, suppliers have taken to adaptation techniques, like using wax covers around rubber trees to avoid contamination during rainy seasons.

Bio Threat: Biological hazards in manufacturing of organic latex, especially during the rainy season, create major challenges for the working population. Worker productivity and safety are affected by hazards including leeches, insects, and snakes. Protective equipment and training on how to handle these hazards will be among the possible mitigation measures.

Hindering Factors in Production Technology

Currently, the company makes mattresses using the Dunlop method. Managers confirmed, the Dunlop method is cost-effective and very easy to apply with find alone measure of the company and human resources as this method does not involve complex or high-level steps and arrangements. (Manager #2)"

Production Capacity: Average 400 blocks in 24 hours, evenly split across day and night shifts. That limited capacity restricts the company's potential to accommodate big export orders.

Quality Restrictions: The softness and density of foam made from the Dunlop method is of lower quality than the Talalay technology [20]. "Manager #1 said, mostly orders from USA are asking for high density mattress foams so the company is unable to cover some high values order".

Time Management problems: With vulcanization, it takes about an hour per mold. Sometimes, the company is forced to postpone orders in order to finish more urgent ones which shows how time-consuming this Dunlop process can be!

Insufficient or No Research and Development: The lack of investment in R&D leads to the organization continuing to use the same technology without any upgrades or innovations, which further narrows their competitive advantage.

Hindering Factors in Labor Productivity

Investigational Environment: Product plant has an exceedingly warm climate from steam trenches and drying machines limiting labor attack and affecting representative health. Factory space is also tight, with no dedicated area for finished mattresses. Workers state they are exhausted working 12-hour shifts and only have half an hour for breaks far in excess of the 8 hours that Sri Lanka Labour Law recommends.

No training: In the absence of any formal training program, new workers will not reach previous working speeds, and therefore will make more mistakes leading to wastage and/or delays in production. As Employee #2 stated: "No training provided by Company. The company basically asks to learn by doing. "Discarded because the mattresses have a number of problems.

Safety and Labour Shortage: Fillers and Fabricators are exposed to latex and chemical substances that can cause allergic responses in some people. Lack of equipment to protect people, risky for health. Having only 26 workers to a shift is hardly enough resources for optimal production.

Manufacturing Practices are such that, the quality check is performed only at the end of stage, faults from previous stages go undetected. A proper checking team at each level would reduce the defect rates to a minimum.

Thematic Analysis Summary

Table 1 summarises the factors, codes and themes that emerged from the thematic analysis of the interview data.

Table 1: Thematic Analysis Summary

Factors	Codes	Themes
Material Supply	C1 - Quality Assurance; C2 - Certification; C3 - Ethical latex production; C4 - Transparency	Sustainability
	C5 - Weather dependency; C6 - Biological hazards; C7 - Adaptation strategies	Environmental Challenges
Production Technology	C8 - Lower amount of foam production; C9 - Density issues; C10 - Time-consuming; C11 - Wastage; C12 - Strength of walls; C13 - Absent of improvement	Limitations in Dunlop Technology
	C14 - Outdated Technology	Lack of Research and Development
Labor Productivity	C15 - Production plant temperature; C16 - Factory space; C17 - Interval while production line continues; C18 - Working hours; C19 - Training; C20 - Safety equipment and machines; C21 - Labor scarcity	Working Environment
	C22 - Quality checking team	Company Manufacturing Practices

DISCUSSION

The scope of this study is the control of supply of natural latex mattresses for the export market. The answers from the suppliers show a high commitment to fulfil the requirements of organic rubber in terms of avoiding fertilizers and chemicals, getting certifications and transparency. However, the availability of the material is limited by weather factors such as latex coagulation due to water contamination in the wet season and lower density in the dry season.

The second barrier to the increase of the production of latex foam was the production technology. The Dunlop method is widely used in Asian countries due to its low maintenance cost and low energy consumption (Ramli et al., n.d.). However, it limits the company's ability to increase production of organic latex foam to meet the export demand. The problems identified are limited production capacity, density limits, too much time required and not enough investment in technology research and development.

Previous study found that adequate illumination and proper working environment are crucial factors influencing labour productivity (Enshassi et al., 2007). The present study showed that personnel were deterred by high production plant temperatures. Training can improve the labour productivity (Jajri & Ismail, 2009) but most of the employees of the studied organization did not get the right training. Flexible work arrangements such as job rotation and flexible scheduling have been shown to boost productivity (Preenen et al., 2015) but the company imposes a constant 12-hour work schedule with insufficient breaks.

CONCLUSION AND IMPLICATIONS

Conclusion

As a result, the increasing global demand for organic mattresses presents an enormous market opportunity for natural latex foam manufacturers. This scenario, in turn, makes it necessary for companies to factor in climate change when developing supply chain and commercial strategies. The three main areas of barriers to economic growth were supply chains for materials, production technician input and labour productivity. Due to rainfall and drought conditions affecting the quality and quantity of latex produced, climate dependence has become the main constraint in supply a situation which begs for timely climate-adaptive procurement and supplier management interventions. Deficiencies in quality compliance and biological threats were also identified.

Production technology. The Dunlop method faced several drawbacks: limited production capacity, quality constraints, inefficient time management and inferior resource allocation for research and development. Yuhui Further reading Labour productivity is limited by insufficient working conditions, lack of training, poor safety equipment and inefficient procedures in industry. Thus the findings jointly point out how much climate change worsens existing operational risks and argue convincingly that sustainability be embedded at the heart of business decision-making. Companies that take a proactive stance and bring their supply chains in line with the realities of the climate will be best able to address sustainable export demand and deliver long-term stakeholder value.

IMPLICATIONS AND RECOMMENDATIONS

Climate change adaptation is incorporated into the supplier management system for material supply suppliers of natural latex foam manufacturers. To help mitigate risk of concentration in climate-sensitive regions, efforts should be made to diversify the supplier base by identifying, on boarding and partnering with other GOLS-certified manufacturers. Rationale: Reward supply partners to adopt climate-smart agricultural practices (e.g., drought-resistant rootstocks, advanced irrigation systems and shade production) Organizations have to build infrastructure to be more resilient for weather-related disruptions. Some of these could provide shelters to collect latex and constantly monitor the climate to prevent disruption during rainy season and droughts. These data-driven demand forecasting tools balance procurement schedules with seasonal climate patterns and help address the volatility of supply itself. Use long-term contracts, enhanced communication and collaboration around climate risk to invest in important supplier relationships leading to improved resilience & sustainability of supply chains.

Production processes, researchers suggest switching from the Dunlop to air micro-bubbling technology. Spectacularly, the foams created by this process can have tensile strengths in the cellular structure on par with Dunlop foams of higher capital intensity than Talalay technology (Table 2).

Table 2: Characteristics of Dunlop and Air Micro-Bubbling Latex Foams

Sample	Tensile Strength (MPa)	Modulus (MPa)	Toughness of Walls (MPa)
Dunlop LF	0.071	0.0170	0.1885
Air Micro-Bubbling LF	0.116	0.0410	0.1935

Source: Raveshtian et al. (2022)

Manufacturers should either launch focused R&D projects or outsource R&D for leveraging expertise and maintaining a competitive edge in vibrant global markets.

Facilitating worker productivity, organizations want to implement advanced HVAC systems for the purpose of regulating temperature in the production room. Space utilization needs to be improved by using layout and lean manufacturing methods on existing space. You need to create a whole training plan for new and existing staff. Job rotation across functions is necessary to provide multi-skill capabilities and at the same time reduce boredom. Each production phase should be assigned a quality assurance team, as well as standard times for the filling, shaping and fabrication phases.

LIMITATIONS

Research resources were limited, making it difficult to find original articles on organic latex mattresses and the manufacture of latex foam. Getting in-person interviews with senior management was tough due to travel itineraries. The corporation did not permit on-site interviews with suppliers, so audio call interviews were carried out. Some of the secondary data were outdated and direct contact with the firm management was necessary to obtain updated data.

AI Tool Disclosure

No artificial intelligence (AI)-assisted tools were used in the preparation of this manuscript.

Ethical Approval

This study involved human participants: seven semi-structured interviews were conducted with company management, production employees and natural rubber suppliers. Ethical approval was obtained from the company. Informed consent was obtained from every participant after full disclosure of the study's goals, the voluntary nature of participation and the confidentiality measures. Participants were free to withdraw at any time without consequence. Responses were anonymised: the case company is not named and quotations are identified only by role codes (for example, Supplier #1, Manager #2, Employee #2). No animals were involved in this research.

Conflict of Interest

The authors declare that they have no known financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors have no commercial affiliation with the case company or its suppliers, and the company had no role in the design of the study, the analysis and interpretation of the data, the writing of the manuscript or the decision to submit it for publication.

Data Availability

The primary data for this study are the interview recordings and transcripts, together with the codes and themes derived from them, which are summarised in Table 1. Because the data contain commercially sensitive information about a single company and its suppliers, and participants were assured of confidentiality, the raw data are not publicly available. The secondary data were drawn from published studies cited in the reference list, the company website and industry documents; the data in Table 2 are reproduced from Raveshtian et al. (2022).

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