INTEGRATING HUMAN SAFETY AND ENVIRONMENTAL PROTECTION INTO SUPPLY CHAIN OPERATIONS FOR A SUSTAINABLE FUTURE

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Abstract

The paper examines the critical success factors for integrating environmental protection and human safety into supply chain operations for a sustainable future. Ninety-one supply chain managers and sustainability officers from the retail, logistics, and industrial sectors completed a questionnaire-based data collection process. The survey examined organizational procedures, perceived obstacles, and facilitators for the integration of environmental and human safety. A thematic analysis of the responses revealed that successful integration requires strong leadership commitment, comprehensive safety management systems, supplier cooperation, and continuous training. Lack of resources and inconsistent standards appeared as major obstacles, although regulatory compliance and stakeholder pressure were also noted as important drives. The results highlight the significance of proactive supplier engagement, integrating environmental and safety objectives into procurement procedures, and cultivating a shared responsibility culture across the supply chain. By highlighting practical elements that businesses can use to improve both environmental protection and human safety in their operations, for a sustainable future, this study contributes to the growing body of knowledge on sustainable supply chain management.

Keywords: *Sustainability, Human Safety, Environmental Preservation, and Supply Shain Management*

Introduction

For organizations looking to operate ethically and sustainably, the growing complexity and globalization of supply chains have presented previously unheard-of opportunities as well as challenges. Stakeholder expectations, legal frameworks, and market dynamics have all significantly changed in recent years, forcing companies to incorporate human safety and environmental protection into their supply chain operations (IBM, 2024; Sedex, 2025). Social responsibility and human safety are equally important. Global supply chains frequently cross areas with different labor laws and regulations, which raises the possibility of human rights abuse like hazardous working conditions, forced labor, and low pay (Sedex, 2025).

Sustainable supply chain management

The practice of integrating environmental, social, and financial factors into each phase of the supply chain, from the procurement of raw materials to the disposal of finished goods, is known as sustainable supply chain management (SSCM) (IBM, 2024). This all-encompassing strategy seeks to ensure operational dependability and efficiency while reducing adverse effects on society and the environment. The environmental dimension includes initiatives to minimize waste, conserve natural resources, and lower greenhouse gas emissions—all of which are essential to halting climate change and protecting ecosystems (IBM, 2024; SAP, n.d.). Conversely, social responsibility entails protecting human rights, guaranteeing moral labor practices, and offering secure working conditions all the way through the supply chain (Sedex, 2025). By controlling expenses and risks, guaranteeing regulatory compliance, and

promoting operational efficiencies that can result in notable cost savings and profitability, financial responsibility connects these efforts (IBM, 2024). Supply chains have a significant environmental impact. Supply chains may be responsible for over 90% of a company's overall greenhouse gas emissions, according to the Carbon Disclosure Project, highlighting the critical need for efficient environmental management at all supplier levels (IBM, 2024).To lessen their impact on the environment, businesses are increasingly implementing strategies like the use of renewable energy, efficient logistics, and the concepts of the circular economy. As demonstrated by the increasing number of companies reporting increased profitability along with sustainability gains, these initiatives not only reduce environmental risks but also improve supply chain resilience and cost efficiency (IBM, 2024). There is a strong business case for incorporating human safety and environmental concerns into supply chain management. Sustainable supply chains can promote innovation, increase operational effectiveness, and boost brand loyalty in addition to risk mitigation and regulatory compliance (IBM, 2024; Law code, 2024). A considerable percentage of consumers are willing to pay more for sustainable products, and consumer preferences are moving toward goods that are both ethically and environmentally produced (Law code, 2024). In conclusion, it is now essential for modern businesses to incorporate human safety and environmental protection into supply chain operations. Organizations can create robust, ethical, and competitive supply chains that benefit society and business by recognizing and taking care of crucial success elements including stakeholder cooperation, risk assessment, and ongoing development.

Literature Review

According to Seuring and Müller (2008), sustainable supply chain management (SSCM) is the management of capital, information, and material flows as well as collaboration between businesses along the supply chain while incorporating objectives from the economic, environmental, and social dimensions of sustainable development, which are closely related to both environmental preservation and human safety. The evolution of sustainability in supply chain management is highlighted by Rajeev et al. (2017), who stresses the increasing significance of incorporating social and environmental factors—including human safety—into operational strategies. Hassini, Surti, and Searcy (2012) address the necessity for supply chain managers to address sustainability by considering environmental and social impacts, such as worker safety and ecological preservation, in their decision-making processes. Ahi and Searcy (2013) emphasize the voluntary integration of economic, environmental, and social considerations as essential for coordinated and sustainable supply chains. According to Brandenburg et al. (2014), performance metrics that include energy, waste, emissions, and social responsibility are used to assess supply chains, demonstrating the importance of both human safety and environmental preservation. Mangla, Madaan, and Chan (2013) discover that risk management, supplier collaboration, and stakeholder engagement are critical success factors for integrating environmental and human safety considerations in supply chain operations. Kumar et al. (2020) identify sustainable design and development, strategic sourcing, efficient technology, and green logistics as critical processes for integrating sustainability—including environmental and human safety—into supply chains. According to Dubey et al. (2017), implementing green supply chain management techniques, such as safe working conditions and environmentally friendly packaging, can greatly improve both human safety and environmental protection (Dubey, Gunasekaran, & Papadopoulos, 2017). However, Beske and Seuring (2014) emphasize the significance of dynamic capabilities—like learning, integration, and reconfiguration—for accomplishing supply chain sustainability goals, including those pertaining to safety and the environment. GSCM includes activities like eco-design, cleaner production, green purchasing, and reverse logistics, all of which enhance environmental performance and resource efficiency, as the literature repeatedly emphasizes (Azevedo et al., 2011). The importance of safety management in supply chains is becoming

more widely acknowledged, since it guarantees both regulatory compliance and the safety of communities and employees against dangerous exposures (Aslinda et al., 2012).

According to Winter and Knemeyer (2013), incorporating sustainability into procurement procedures, including supplier evaluation and selection—is essential to guaranteeing adherence to environmental and human safety norms. While Fahimnia et al. (2015) emphasizes the creation of quantitative models that support decision-making for sustainable supply chains with an emphasis on lowering environmental impact and improving workplace safety, Pagell and Wu (2009) find that companies that prioritize safety and environmental objectives throughout their supply chains typically experience improved operational performance and stakeholder satisfaction. Carter and Rogers (2008) state that supply chain partners can benefit in the long run from the strategic integration of environmental and social policies, such as pollution prevention and safe working conditions. According to Sarkis and Lai (2011), green supplier development initiatives that prioritize capacity building and training are crucial for guaranteeing that suppliers follow safety and environmental regulations. According to Vachon and Klassen (2006), cooperative efforts, like combined safety training and environmental management programs, are successful in reaching integrated sustainability objectives throughout supply chains.

Research questions of the Study

1. What are the main elements affecting how supply chain operations incorporate human safety?
2. How does supply chain performance change when environmental protection measures are put into place?
3. How do supply chain management strategies for environmental preservation and human safety relate to each other?
4. Which crucial success characteristics best indicate how well supply chains can integrate environmental protection and human safety?

Research objectives of the Study

1. To examine the key elements which support human safety in supply chain operations.
2. To investigate how supply chain performance is affected by environmental conservation measures.
3. To investigate how supply chain environmental protection activities and human safety measures interact.
4. To identify the most important crucial success criteria for supply chain management's integration of environmental protection and human safety.

Research Hypotheses

H1: The integration of human safety practices in supply chain operations is enhanced by the existence of explicit safety policies.

H2: Better supply chain performance is positively correlated with the adoption of environmental protection measures.

H3: Initiatives for environmental protection and human safety in supply chains are closely related.

H4: The successful integration of environmental protection and human safety is strongly predicted by critical success elements (e.g., management commitment, employee training).

Research Methodology of the Study

A questionnaire-based method was used to gather data. The closed-ended answers were made possible by the semi-structured nature of the inquiry. Participants were able to expound on their perspectives and experiences with the incorporation of human and environmental safety procedures in supply chain operations thanks to this format. Participants with appropriate knowledge and experience in supply chain management and sustainability were chosen using purposeful sampling. Ninety-one supply chain managers and sustainability officers from the manufacturing, logistics, and retail industries made up the sample. The questionnaire was sent online to participants to make it more convenient and to promote honest answers. Important topics included in the questionnaire included organizational safety and environmental protection procedures, perceived obstacles and difficulties, integration facilitators and motivators, and successful initiative examples. Data Analysis was done by SPSS- 21 Software and the Chi-square test or t- test, Correlation and Multiple regression.

Table .1

		N	%
Cases	Valid	89	97.8
	Excluded[a]	2	2.2
	Total	91	100.0

Test of Reliability

Table .2

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of Items
.818	.819	15

Reliability statistics for 15-item survey are shown in the table. The items show strong internal consistency, meaning that the questions consistently assess the same underlying construction, as indicated by the reported Cronbach's Alpha of 0.818. Values greater than 0.8 are frequently considered favorable, suggesting that the scale is suitable for further research and that participant answers to the items are reliable.

Reliability of the Item wise

Table .3

Statistics			
	Mean	Std. Deviation	N
The leadership of our company is dedicated to incorporating human safety into supply chain management.	3.19	.810	89
Initiatives to protect the environment are actively supported by top management.	3.33	1.106	89
Our supply chain has well-defined safety management mechanisms in place.	3.29	1.002	89
We frequently train supply chain employees in safety.	3.43	1.096	89
To accomplish safety and environmental objectives, supplier cooperation is encouraged.	3.44	1.087	89
Our supply chain incorporates environmental protection measures including waste minimization and emissions control.	3.31	.949	89

One of the main forces behind our safety and environmental activities is regulatory compliance.	3.42	1.031	89
Pressure from stakeholders (investors, customers, etc.) affects our supply chain procedures.	3.44	1.033	89
Our capacity to adopt environmental and safety procedures is hampered by a lack of resources.	3.33	.997	89
Integration is hampered by inconsistent standards across vendors.	3.34	.988	89
Environmental and safety requirements are part of our purchase process.	3.30	1.005	89
We have a common culture of accountability for environmental preservation and safety.	3.48	1.088	89
Our supply chain's performance has improved because of integrating safety and environmental goals.	3.39	1.029	89
We actively work with vendors to enhance	3.29	1.002	89
Our supply chain has well-defined safety management mechanisms in place.	3.31	1.154	89

H1: *The addition of clear safety policies improves the integration of human safety measures in supply chain activities*.

Table .4

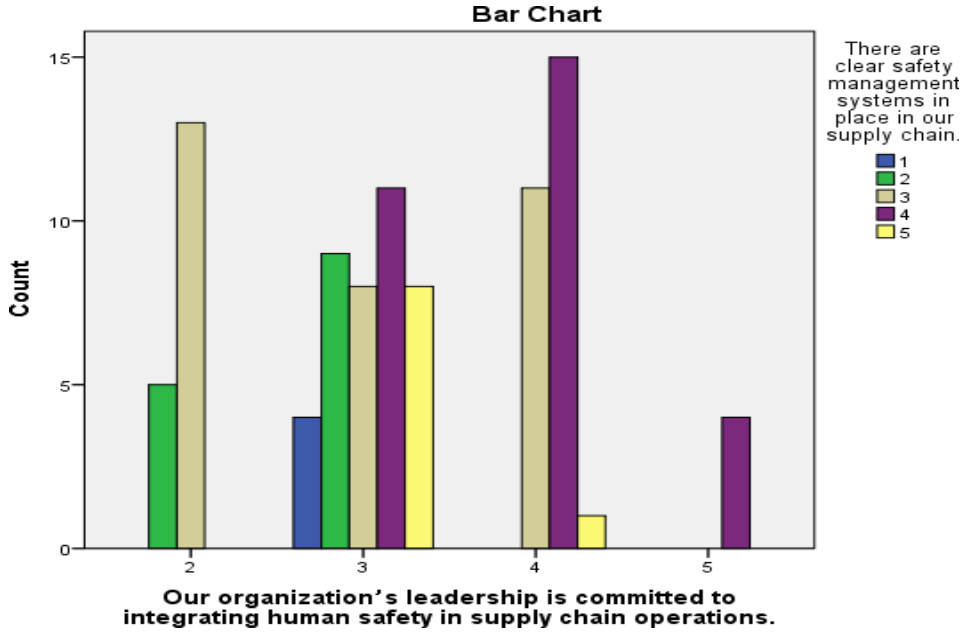
Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	46.381[a]	12	.000
Likelihood Ratio	58.140	12	.000
Linear-by-Linear Association	10.802	1	.001
N of Valid Cases	89		

Analysis

The significance level (Asymp. Sig., 2-sided) is.000, and the Pearson Chi-Square value is 46.381 with 12 degrees of freedom. A statistically significant relationship between the two examined categorical variables is indicated by this p-value, this is much less than the conventional limit of 0.05. The Likelihood Ratio test, which produces a result This result is further supported by a p-value of.000 and a value of 58.140 with the same degrees of freedom. However, it is remarkable that 13 cells (65.0%) had expected counts of at least 0.18 and fewer than 5. The accuracy of the results could be compromised because this goes against one of the Chi-square test's presumptions. Results should be interpreted cautiously because the accuracy of the test may be compromised when a significant percentage of cells have low expected numbers.

Figure 1

In summary, the factors are statistically significantly correlated. However, the results should be interpreted cautiously because there are many cells with low predicted counts; alternate tests or data grouping may be taken into consideration.



H2: *Better supply chain performance is positively correlated with the adoption of environmental protection measures*.

Table .5

Correlations				
	Our supply chain incorporates environmental protection measures including waste minimization and emissions control.			Our supply chain's performance has improved because of integrating safety and environmental goals.
Spearman's rho	Our supply chain incorporates environmental protection measures including waste minimization and emissions control.	Correlation Coefficient	1.000	.826
		Sig. (2-tailed)	.	.000
		N	91	91
	Our supply chain's performance has improved because of integrating safety and environmental goals.	Correlation Coefficient	.826	1.000
		Sig. (2-tailed)	.03	.
		N	91	91

Analysis:
Correlation Coefficient
The two variables have a Spearman's rho correlation of 0.826.

This value shows a strong positive association, indicating that Enhancements in supply chain efficiency by combining environmental and safety objectives are also more likely to occur as environmental protection methods become more fully integrated into the supply chain.

Statistical Significance

Significantly smaller than the conventional limit of 0.05, the significance value (Sig. 2-tailed) is.000.
This suggests that the relationship is statistically positive, significant and unlikely to be the product of possibility.

The Analysis

Improved supply chain performance because of integrating safety and environmental objectives is strongly and statistically significantly positively correlated with the integration of environmental protection strategies.

H3: *Initiatives for environmental protection and human safety in supply chains are closely related.*

Table .6

Correlations					
			We frequently train supply chain employees in safety.	To accomplish safety and environmental objectives, supplier cooperation is encouraged.	Integration is hampered by inconsistent standards across vendors.
Spearman's rho	We frequently train supply chain employees in safety.	Correlation Coefficient	1.000	.499	.801**
		Sig. (2-tailed)	.	.000	.004
		N	91	91	91
	To accomplish safety and environmental objectives, supplier cooperation is encouraged.	Correlation Coefficient	.899	1.000	.623*
		Sig. (2-tailed)	.000	.	.003
		N	91	91	91
	Integration is hampered by inconsistent standards across vendors.	Correlation Coefficient	.801**	.623*	1.000
		Sig. (2-tailed)	.004	.003	.
		N	91	91	91

Analysis:

The correlation matrix reveals strong positive relationships among the three variables in this supply chain study with 91 observations. "We frequently train supply chain employees in safety" shows a very strong correlation ($\rho = .801$, $p = .004$) with "Integration is hampered by inconsistent standards across vendors," and a strong one ($\rho = .499$, $p = .000$) with "To accomplish safety and environmental objectives, supplier cooperation is encouraged,"

indicating that regular safety training aligns closely with both tackling vendor inconsistencies and promoting supplier collaboration. Similarly, supplier cooperation exhibits a strong positive link (ρ = .623, p = .003) with overcoming vendor standard inconsistencies, while each variable perfectly correlates with itself (ρ = 1.000). All significant p-values (p < .01 or p < .05, marked by ** or *) confirm these Spearman's rho associations are unlikely due to chance, suggesting that safety training, supplier engagement, and standardized vendor practices mutually reinforce each other toward safer, more integrated supply chain operations.

H4: *The successful integration of environmental protection and human safety is strongly predicted by critical success elements (e.g., management commitment, employee training)*

Table .7

Model Summary[b]									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.884[a]	.781	.771	.493	.781	74.905	4	84	.000

Analysis of Model

R (Correlation Coefficient):
The set of independent variables and the dependent variable a very strong and the R value of 0.884 indicates a positive association.

R Square

The R Square value is determined by accounting for the overall number of predictors in the model, yielding an Adjusted R Square of 0.771. This figure demonstrates that even after taking the number of variables into consideration, the model is still robust.

Adjusted R Square

The standard error, which is 0.493, indicates the average distance between the values that were observed and the regression line. A lower score indicates a better model match.

Change Statistics (F Change, Sig. F Change):

The model is statistically significant, and the independent factors greatly enhance the prediction of the dependent variable, as indicated by the F Change of 74.905 at a significance level of.000.

Table .8

Coefficients[a]					
Model		Unstandardized Coefficients		Standardized Coefficients	t
		B	Std. Error	Beta	
1	(Constant)	.521	.286		1.695

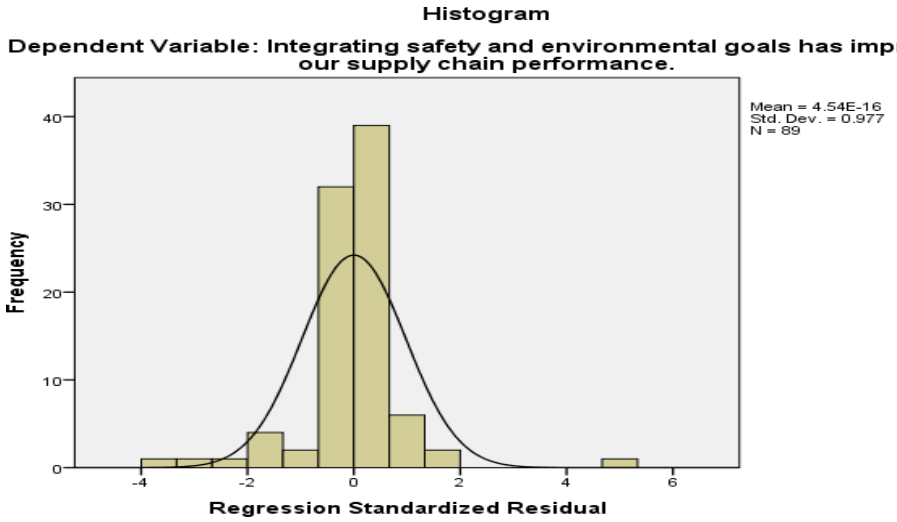
	The leadership of our company is dedicated to incorporating human safety into supply chain management.	.085	.069	.067	1.239
	Initiatives to protect the environment are actively supported by top management.	.051	.050	.055	1.028
	To accomplish safety and environmental objectives, supplier cooperation is encouraged.	.839	.050	.885	16.736
	Our supply chain has well-defined safety management mechanisms in place.	.024	.047	.027	.512

Table .9

Coefficients[a]					
Model		Sig.	Correlations		
			Zero-order	Partial	Part
1	(Constant)	.006			
	The leadership of our company is dedicated to incorporating human safety into supply chain management.	.001	.072	-.134	-.063
	Initiatives to protect the environment are actively supported by top management.	.000	.006	.111	.052
	To accomplish safety and environmental objectives, supplier cooperation is encouraged.	.000	.880	.877	.854
	Our supply chain has well-defined safety management mechanisms in place.	.001	.220	.056	.026

Key Findings

Among the factors examined, supplier collaboration is the strongest and most distinct predictor of the result, as evidenced by its greatest zero-order (.880), partial (.877), and part (.854) correlations. Leadership Engagement, upper-management support, and regular instruction exhibit much lower zero-order, partial, and part correlations as compared to supplier collaboration, suggesting that their individual contributions to explaining the outcome are extremely small. Although every predictor is statistically significant and contributes significantly to the model, supplier cooperation is probably the most important.



Interpretation

Improved supply chain performance is positively correlated with the integration of environmental protection policies (Spearman's rho = 0.826, p <.001). This suggests that when safety and environmental objectives are combined, organizations that actively implement environmental measures typically see higher performance improvements. Regular safety training and the integration of environmental protection methods have a small but considered significant positive connection value are (rho = 0.199, p = 0.000). The above variable supplier standards as a challenge have a high, statistically significant positive link (rho = 0.801, p = 0.004), indicating that organizations that prioritize training are very cognizant of integration difficulties. The Environmental prevention methods and identifying inconsistent criteria as a difficulty have a moderately strong positive link (rho = 0.623, p = 0.003). The multiple regression model explains 78.1% of the variation and demonstrates a very significant correlation "R = 0.884, R^2 = 0.781" between the collection of predictors and better SC performance. The most significant and distinctive element among all the predictors is supplier collaboration; top management support, leadership commitment, and ongoing training all have a substantial but smaller contribution.

Conclusion

This study demonstrates that including protecting the environment and human safety protocols into supply chain operations greatly improves supply chain performance. The investigation's findings demonstrated a major, a substantial, statistically significant positive relationship between improved performance outcomes and the implementation of environmentally friendly measures. Supplier collaboration was found to be the most significant predictor among the important success elements analyzed; leadership commitment, top management assistance, and ongoing training also made significant contributions. On the other hand, companies that take a proactive approach to environmental and safety activities are more likely to identify issues like varying standards across suppliers. In general, achieving sustainable and secure supply chain operations requires cultivating solid partnerships and a culture of continual improvement.

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