ASSESS THE IMPACT OF LEAN METHODS AND TOOLS ON THE ENVIRONMENTAL PERFORMANCE OF DISTRIBUTION INDUSTRIES

Author 1 : N.Tamilvanan, Research scholar, Department of mechanical engineering, PSG College of technology, coimbatore -641004.

Author 2 : Dr.S.Syath Abhuthakeer , Associate professor, Department of mechanical engineering, PSG College of technology, coimbatore -641004.

Abstract: In recent days, lean methods have been highly used to improve the growth of the industry. Many existing research works investigated the effect of lean methods in different industries. Nevertheless, existing research works failed to investigate the effect of lean methods and tools on the environmental performance of the distribution industry. Hence, this research work investigates the effect of lean methods and tools on the environmental performance of the distribution industry. The research work selects the lean methods according to the distribution industry. Also, the study is a quantitative research study and descriptive analysis. So, the research work follows some strategies to choose the respondents. The target of the research is to focus on more number of distribution industries. In total, 287 respondents are selected with the help of publically available reports. The experimental result of the research shows that the PT, TT, FIFO, TQM, and TPM attain higher results than the other methods concerning environmental measures. The research framework contributes to a better understanding of lean practices, which help companies to develop strategic initiatives towards environmentally.

Keywords: *Distribution industry, Lean methods and tools, Environmental performance, Descriptive analysis, Quantitative analysis, Sustainable transportation practices, and package waste.*

1. INTRODUCTION

Currently, there is increased competition is presented in between the companies. Therefore, every company needs to adopt new technologies to increase productivity and find solutions for improving the flexibility of its distribution system (Kihel et al., 2022). Hence, most of the research studies focused on lean manufacturing implementation in their business (Adzrie et al., 2020). The lean approaches are used to maximize productivity by eliminating the wasted effort, energy, and materials generated from non-value-added activities (Tripathi et al., 2021). Environmental performance is a holistic consideration of all environmental aspects in the distribution industry (Juma et al., 2021). So, the adoption of the lean method by considering environmental performance is necessary. The lean method as a philosophy is people-centric relying on supportive business culture, people, and employee involvement (Vlachos et al., 2023). Lean methods and tools are used in various sectors, such as the manufacturing sector, distribution sector, healthcare sector, construction sector, and so on (Amrani & Ducq, 2020). Among the various sectors, lean methods and tools are widely used in the manufacturing, distribution, and healthcare sectors (Ruwanpura et al., 2023). With the help of lean implementation, the deliveries are done according to the defined deadlines, enhanced quality, and increased trust in the supplier-client relationship (Dos Santos et al., 2021). Different types of lean methods and tools, such as Just in Time (JIT), Kaizen, Value Stream Mapping (VSM), Total Productive Maintenance (TPM), and so on, are used for the distribution sector (Valamede & Akkari, 2020). However, ineffective selection of lean methods and tools leads to inconsistency problems in the distribution sector (Khoza et al., 2022). Hence, the selection

of lean methods and tools is very important. So, this research methodology studies the effect of lean methods and tools on the environmental performance of the distribution industry.

1.1 Problem statement

Existing research works have some research problems, which are listed here,

- Existing research works failed to analyze the effect of the implementation of lean methods and tools on the environmental performance of distribution industries.
- Existing research work (Singh et al., 2020) only assessed the specific lean tools and methods.
- The distribution industry performance varied based on different factors, where location was also one of the important factors. Existing (Novais et al., 2020) failed to consider various location-based industries utilizing lean methods.
- Existing research work (Ribeiro et al., 2022) failed to assess the combination of lean tools for the improvement of industry performance.
- Most of the existing research works failed to assess the relationship between lean practices and energy efficiency in the distribution sector.
- Existing research works did not concentrate on the lean-based supply chain practices on the environmental performance of the distribution industry.

1.2 Objectives

The proposed research work has some research objectives, which are discussed as follows,

- To assess the effect of the implementation of lean methods and tools on the environmental performance of the distribution industry.
- To analyze different lean methods and tools, such as Poke-Yoke (PY), Takt Time (TT), First-In-First-Out (FIFO), Total Quality Management (TQM), Total Productive Maintenance (TPM), JIT, and Human Resource Management (HRM).
- To assess the effect of lean implementation on the environmental performance of the distribution industry by data collected from different regions.
- To analyze the combination of different lean tools and methods to enhance the performance of the distribution industry.
- To assess the relationship between lean practices and energy efficiency in the distribution sector.
- To measure the environmental performance of lean-based supply chain practices in the distribution industry.

The structure of the proposed research paper is organized here: In section 2, the existing lean method implementation is explained, in section 3, the proposed research methodology is given, in section 4, the experimental performance of the research is given, and in section 5, the proposed research work is concluded with future scope.

2. LITERATURE REVIEW

(Novais et al., 2020) examined the role of cloud computing technology used in logistics and analyzed the effect of logistics in lean manufacturing management and supply chain

integration contexts. The research work selected 260 companies for the assessment. Also, the framework used Structural Equation Modelling (SEM) to test the hypotheses. The findings of the research showed that the model achieved better business results in lean production environments. However, the research framework only covered a specific geographical area.

(Ghaithan et al., 2021) explored the integrated impact of industry 4.0 technologies and lean manufacturing on sustainability performance. For the primary data collection, the research work used the questionnaire design. The hypothesis of the research was analyzed using SEM. The outcome of the research showed that lean manufacturing had a positive impact on sustainability performance. The country selected for the research was new for industry 4.0 technologies; so, the respondents' knowledge of industry 4.0 technology was limited.

(Singh et al., 2020) intended to apply the lean manufacturing approach in packaging companies in Bangladesh for improvement of overall performance. Different key performance indicators were used to analyze the productivity enhancement in different processes. The research showed that the Value Stream Mapping (VSM), Kanban, and Single-Minute-Exchange-of-Die (SMED) approaches provided significant improvement based on key performance indicators. However, the research work failed to concentrate on other types of lean methods and tools.

(Markulik et al., 2024) intended to assess the possibility of applying quality tools used in regular serial production in specific conditions of piece production in a small company. The research framework used comparison analysis to obtain suitable lean methods and tools for the organizations. The research outcomes only supported small and medium companies.

(Ribeiro et al., 2022) evaluated the degree of implementation of lean and green practices in Portuguese manufacturing companies. The research framework was based on the questionnaire design and distribution. In total, 158 answers were collected from the distributed questionnaires. From the exploratory analysis, 10 factors were extracted. The outcome of the research study confirmed that the adoption of Lean and Green practices improved the performance of the industry. Nevertheless, the research failed to assess the combination of lean tools for the improvement of the industry performance.

3. RESEARCH METHODOLOGY

This research work investigates the effect of lean methods and tools on the environmental performance of the distribution industry. The research study is based on quantitative analysis. The primary data of the research is collected by the distribution of questionnaires. The secondary data are collected by reviewing the prevailing articles and reported case studies. The structure representation of the research study is given in Figure 1.

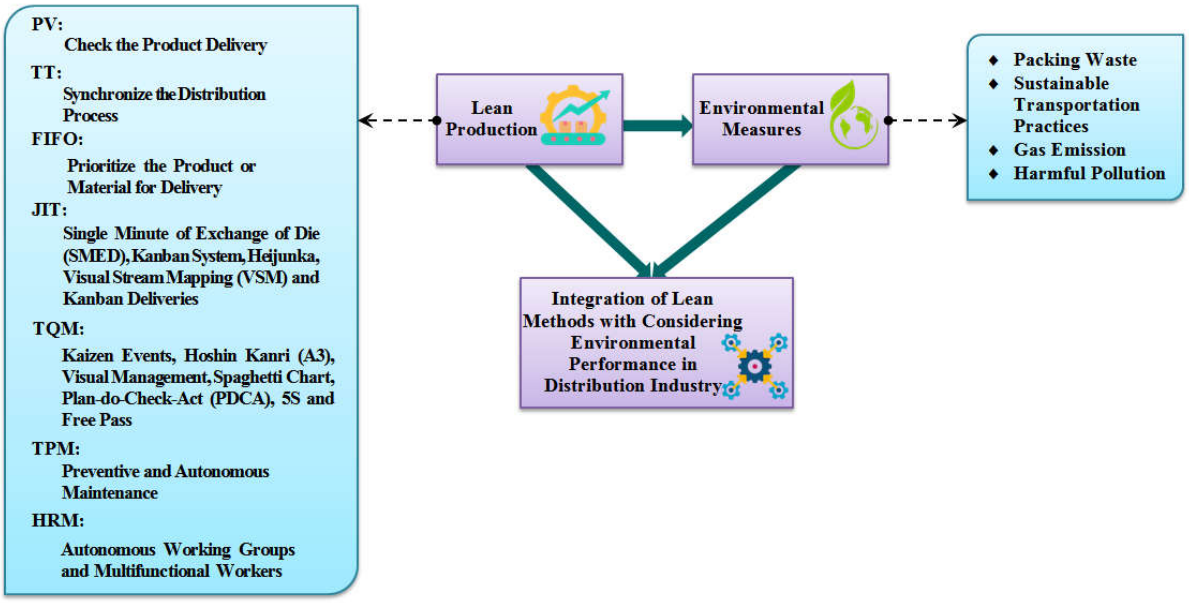

Figure 1: Structural representation of the presented research study

3.1 Data collection

The analysis of the research is mainly based on the quantitative data collection. The quantitative analysis provides measurable and objective data that can be analyzed statistically. The secondary data is collected from the reports of industries, articles, and case studies about lean practices used in the industries. The sources are collected from the publically available sources. Initially, the primary data is collected by considering various factors, such as region of industry, years of experience in using lean methods, age of the company, success rate of the company, and so on.

Selection strategy: Many companies provide reports about lean methods' implementation in publically available resources, such as blogs, articles, and case studies. Concerning those resources, nearly 400 distribution industries are selected. Among the selected 400 industries, only 287 companies responded and accepted the collection of data about lean methods and tools. Then, the key stakeholders, such as managers, Lean experts, distributors, and sustainability officers, involved in the lean implementation are considered for the interview. The data collection strategy follows the purposive sampling technique. The data collection is the open-ended surveys. Initially, all the respondents are interviewed to ensure that they have knowledge about the physical business characteristics of the company.

Questionnaire sections: The questionnaire has three sections, such as details of the distribution industry, details of lean methods and tools used in their distribution industry, and details of the environmental performance in the implementation of lean methods and tools. The first section is helpful to know the region of the industry, years of experience in using lean methods, age of the company, success rate of the company, and so on of the industry. The research work randomly chooses industries from various regions. The second section is useful to know about the adoption of different lean methods and tools used in the industries. Lastly, the third section is helpful to know about the environmental performance of lean methods with energy efficiency and lean-based supply chain practices in the distribution industry.

3.2 Lean methods and environmental measures

The research study considers seven lean methods and tools, such as PY, TT, FIFO, TPM, TQM, JIT, and HRM metrics. Also, five environmental performance metrics are considered, such as packaging waste $\left(\delta_{pwas}\right)$, sustainable transportation practices $\left(\aleph_{sp}\right)$, Gas emission $\left(\Re^{gas}\right)$, and harmful pollution $\left(\Im^{hp}\right)$.

PY: This tool is helpful for ensuring that the correct products are picked, packed, and shipped to the right location.

TT: This tool is helpful for synchronizing the distribution processes with customer needs, and it ensures that the work is done without delays.

FIFO: FIFO ensures that the oldest products are processed and shipped first, and it reduces inventory imbalances.

TPM: The TPM is improving the performance of the systems in the distribution industry, and it ensures the smooth, efficient, and safe operation of systems.

TQM: This tool is significantly improving the process by focusing on customer satisfaction, continuous improvement, and eliminating waste.

JIT: This tool minimizes waste, reduces inventory levels, and ensures that the material and products are delivered or produced only when needed in the distribution process.

HRM: The HRM lean tool improves employee engagement in the distribution of materials and products.

The derivation for the environmental measures is given in below equations,

$$\Re^{gas} = \Delta\ell^{rdu} + \Delta\ell^{rmw} + \Delta\ell^{ip} \tag{1}$$

$$\Im^{hp} = \beta^{ef} + \beta^{gg} + \beta^{ec} \tag{2}$$

$$\aleph_{sp} = \sum \varphi \times SC_{com} \tag{3}$$

$$\delta_{pwas} = \left(T_{mu} - R_{pm}\right) + H_{loss} + D_{pp} \tag{4}$$

Where, $\Delta\ell^{rdu}$, $\Delta\ell^{rmw}$, and $\Delta\ell^{ip}$ denote the reduction in energy usage, reduction in material waste, and reduction in inefficient process, respectively, β^{ef}, β^{gg}, and β^{ec} specify the emission factor, waste generation, and excess energy consumption, respectively, φ specifies the weight value, and SC_{com} denotes the components of sustainable practices, T_{mu} represents the total packaging material used, R_{pm} specifies the required packaging materials, H_{loss} represents the handling loss, and D_{pp} specifies the damaged packaging.

3.3 Analysis technique

The statistical analysis methods are used to analyze the collected data, and correlation is also evaluated to identify the relationship between the tools and the environmental performance of

the distribution industry. The case study analysis is also helpful for validating the findings of the presented research in the lean distribution industry. The research outcome is analyzed and discussed in the further section.

4. RESULT AND DISCUSSION

Here, the outcome of the collected data is analyzed. This part shows the result of lean methods and tools implementation on the environmental performance of the distribution industry.

4.1 Preliminary analysis

Here, lean practice is initially analyzed. Then, the descriptive statistical analysis for each lean method and environmental measure is carried out.

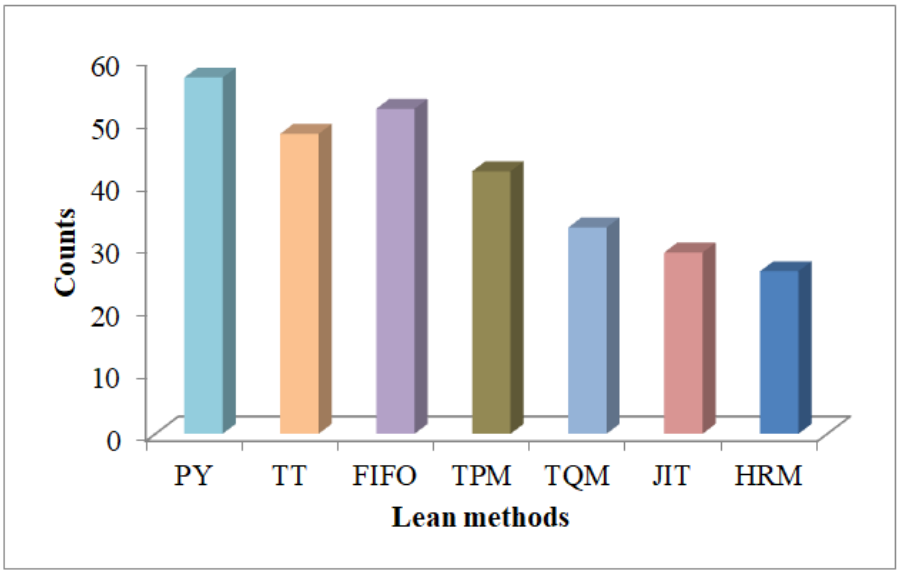

Figure 2: Lean practice assessment in the distribution industry

Figure 2 presents the assessment of lean practices used in the distribution industry. The analysis reveals how many industries follow different types of lean practices in the distribution industry. A higher count of companies presented use PY, FIFO, and TT lean practices for distributing their product or materials. The least number of companies use the HRM tools. The data are collected from different regions.

Table 1: Descriptive statistics assessment

Latent variables	Observed variables	Mean	Standard deviation	Skewness	Kurtosis
Lean methods	PY	3.18	1.321	0.253	-0.953
	TT	3.21	1.212	0.312	-0.874
	FIFO	3.24	1.367	0.121	-1.234
	TPM	2.96	1.315	-0.385	-1.568
	TQM	3.13	1.400	-0.001	-0.745
	JIT	2.87	1.285	-0.265	-0.534
	HRM	2.62	1.329	0.423	-1.231
Environmental Measure	Packaging waste	3.28	1.074	-0.694	0.032
	Sustainable	3.45	1.175	-0.523	-0.396

	transportation practices				
	Gas emission	2.13	1.302	0.194	-1.492
	Harmful pollution	2.07	1.242	0.238	-1.407

Table 1 displays the descriptive analysis, such as mean, standard deviation, skewness, and kurtosis value for the lean methods and the environmental measures. With respect to the lean methods, FIFO, TT, and PY present higher mean values, meaning more progress in implementation because the measures are highly related to the distribution industry. The JIT and HRM attain the lowest mean value. The environmental measures, namely sustainable transportation practices and packaging waste obtain higher mean values. The analysis reveals the relationship between lean methods and environmental measures in the distribution industry.

Table 2: Composite reliability and Cronbach's alpha analysis

Lean methods	Composite reliability	Cronbach's Alpha
PY	1.000	1.000
TT	0.986	0.784
FIFO	1.000	1.000
TPM	1.000	1.000
TQM	0.909	0.763
JIT	0.882	0.672
HRM	0.763	0.491

Table 2 shows the composite reliability analysis of the lean methods. The PY, FIFO, and TPM attain the higher composite reliability value and Cronbach's alpha. Even though the remaining lean methods have a lower value, they also have fairly good reliability (i.e., composite reliability value >60).

4.2 Analyzing the relationship between lean methods and environmental factors in the distribution industry

In this sub-section, the relationship is analyzed based on the correlation, respondent counts, and a combination of different lean methods.

Table 3: Correlation analysis between the lean methods and environmental measures in the distribution industry

Lean methods/Environmental measures	δ_{pwas}	$\aleph_{sp}$	$\Re^{gas}$	$\Im^{hp}$
PY	.256*	.187*	.219**	.162*
TT	.195*	.098	.162	.157
FIFO	.203*	.224*	.273*	.252**
JIT	.097	.067	.176*	.192
TQM	.102	.176*	.084	.109
TPM	.093	.187*	.195*	.164*

HRM	.065	.093	.025	.056

*-Correlation is significant at the 0.01 level
**-Correlation is significant at the 0.05 level

Table 3 shows the outcome of the correlation analysis between the lean methods and environmental measures in the distribution industry. Mostly, the HRM, JIT, TQM, and TPM are not affected by the environmental measures. The PY, TT, and FIFO significantly affect the environmental measures.

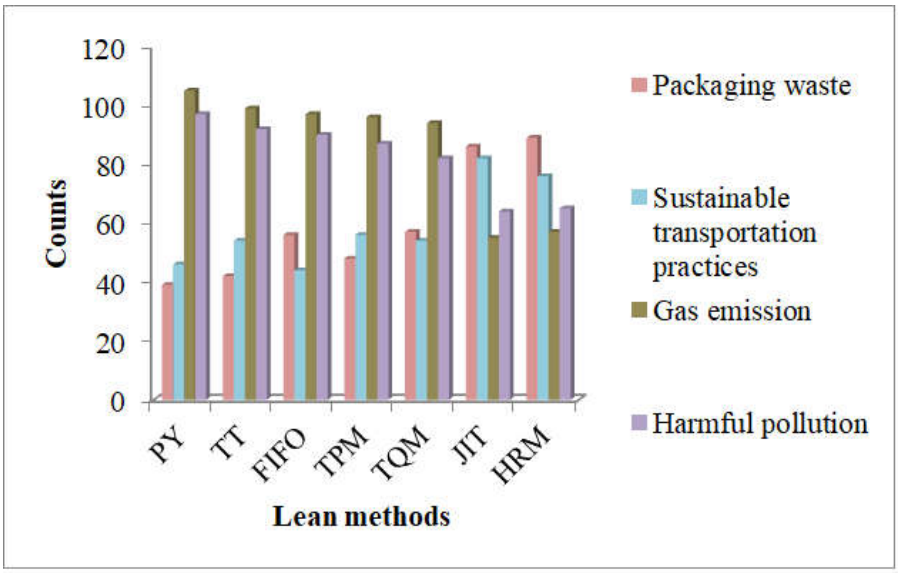

Figure 3: Lean method analysis with respect to the environmental measures

Figure 3 depicts the pictorial representation of the lean method analysis with respect to the environmental measures. Here, the lowest number of the respondents agreed that sustainable transportation practices and packaging waste environmental measures are due to the usage of lean methods. Numerous respondents agreed that the gas emission and harmful pollution measures are due to the usage of lean methods.

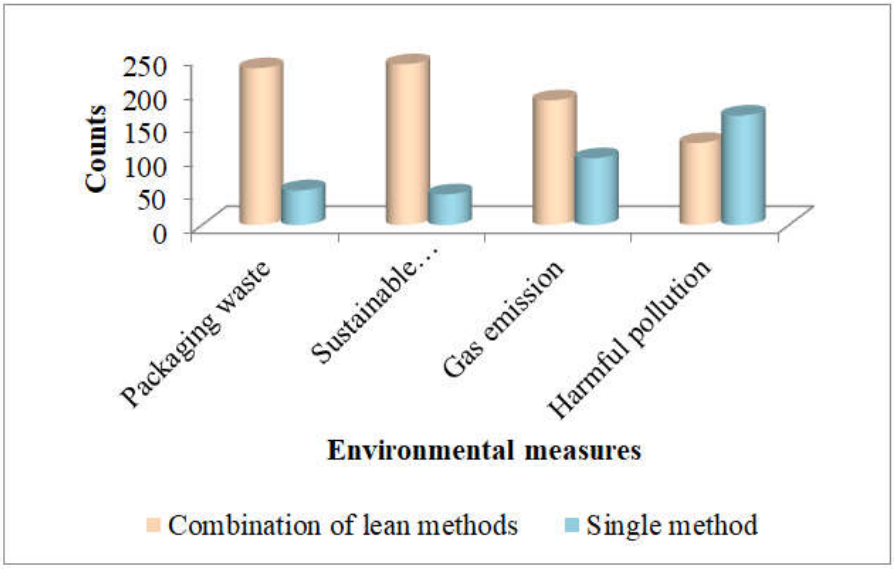

Figure 4: Analysis of the relationship between the environmental measures and the combination of lean methods

Figure 4 shows the relationship between the environmental measures and the combination of lean methods. Most of the respondents accept that the usage of combined lean methods improves packaging waste, sustainable transport practices, gas emission, and harmful pollution than the single lean methods. Hence, the analysis displays that the combination of lean methods is highly suitable for the distribution industries.

4.3 Analysis of lean-based supply chain practices on the environmental performance of the distribution industry

In this section, the lean-based supply chain practices on the environmental performance of the distribution industry are assessed.

Table 4: Lean-based supply chain practice assessment

Environmental measures	With Lean-based supply chain practices (efficiency in %)	Without lean-based supply chain practices (efficiency in %)
Packaging waste	92%	23%
Sustainable Transportation practices	97%	52%
Gas emission	86%	21%
Harmful pollution	65%	47%

Table 4 shows the performance of the lean-based supply chain practices on the environmental performance in the distribution industry. Here, based on the packaging waste and sustainable transportation practice measures, the lean-based supply chain practice achieves higher efficiency than the without lean-based supply chain practices. The analysis proves that the lean method achieves higher environmental performance than the general supply chain practice.

4.5 Case study

The lean methods are used to eliminate waste and simplify activities that add value to products from a customer perspective in the distribution sector. Hence, prevailing research studies presented the implementation of lean methods in their industries. Existing (Agyabeng-Mensah et al., 2020) used some lean implementation methods in the manufacturing industry. The investigation of the study showed that the lean method indicated low process efficiency due to not considering the main lean methods with respect to the specific industries. Existing (Kovilage, 2021) presented the research study related to the lean methods used in the industry for sustainable performance assessment. The study revealed that the selection of lean methods based on the characteristics of the industry improved employee commitment, delivery time, and morale. Similarly, existing (Wu et al., 2022) presented the investigation of lean methods in firms. The study achieved sustainability performance by considering specific characteristics of the firms. Hence, the presented research methodology selects the lean methods according to the distribution industry and provides the experimental outcome for gaining knowledge of lean methods in the distribution industry.

5. CONCLUSION

This paper investigates the effect of lean methods and tools on the environmental performance of the distribution industry. The main objective of this research work was the assessment of lean method adoption in the distribution industry. The research work was evaluated based on seven lean methods and four environmental measures. PY, TT, FIFO, TPM, TQM, JIT, and HRM were the lean methods, and Packaging waste, Sustainable transportation practices, Gas emission, and Harmful pollution were the environmental measures. The investigation was based on the structured questionnaire designs. The analysis showed that the lean methods were performed according to the characteristics of the company. The PY, TT, and FIFO lean methods were highly related to the distribution industry. Hence, most of the respondents agreed with these three methods rather than other lean methods. Also, the combination of lean methods achieved better results when compared to using single lean methods. Then, the lean method-based supply chain practice in the distribution industry achieved higher efficiency than the without considering the lean method-based supply chain practice. However, the research only focused on four environmental factors and the distribution industry.

Future scope: In the future, the research will be extended by considering numerous environmental measures and other industries.

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