

Assessment Framework for Lean-Sustainability Practices in Pottery Industry

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Abstract

This research paper aims to understand lean-sustainability enablers, criteria, and attributes in the pottery industry and develop an assessment framework for lean sustainability. For this framework, a multi-grade fuzzy approach and importance-performance analysis are used. The case study has been conducted at the case pottery unit located in India. The lean-sustainability index value for the case pottery unit is 8.01, which belongs to the 'very highly lean-sustainable practices' level. The identified weaker attributes for the case-pottery unit are supplier readiness and maintenance. Suggestions are provided to improve the weaker attributes. The developed framework helps pottery unit managers to improve their lean-sustainability practices.

Keywords

Lean-Sustainability, Lean practices, Rural industries, multi-grade fuzzy and Importance Performance Analysis.

1. Introduction

India is a country with a rich culture of several traditional products, with pottery being one of the most prominent and quality items being exported to almost 140 countries. In the year 2019-20, the pottery industry in India exported around 9.97 million USD of products to other nations (Rai., 2020). However, the industry, when overlooked, experiences several problems which can be resolved to enhance productivity and revenue and improve the worker's state of affairs. Mahatma Gandhi once said, "If small-scale industries are established, then people would not face problems with production or external markets." (Kaur and Singh, 2015). Small-scale industries are an important sector that rolls out numerous products that benefit both the customer and the manufacturer. These products range from daily grocery items to well-crafted handicraft items. Pottery is one such example where we can club it into the daily needs of the people as well as showcase it as a handicraft item. Also, pottery units face difficulties in selling their cooking utensils in the market in India (Suresh, 2015). Pottery units are available all over the nation, but these industries are under great stress today due to the rising competitive products from big industries and also the fast-moving lifestyle of our citizens. These units are now vulnerable to the extent of shutting down their operations if not well promoted or supported.

The pottery units are mainly run by traditional families or groups who are skilled in the pottery manufacturing industry. They have inherited the culture and the skills to carry on the businesses that benefit both the environment and society as well as themselves. However, the emergence of new generations of industries adopting modern business practices has rolled out reliable and lasting products at a competitive price. This dynamic shift has caused the pottery units to lose their businesses, and they are on the verge of shutting down due to low sales volume. This would mean the death of a traditional business culture that is inherent to India and also the loss of an environment-friendly product that is viable for the polluted mother earth. The study was conducted on how to keep the business sustainable in the changing environment and how to keep a competitive nature for these traditional businesses with the new world's business practices. Or in simple words, it is integrating traditional business technology with modern world developed business practices to bring up the manufacturing units.

The research was done using a multi-grade fuzzy approach, which is explained in Section 3 of this research paper. The enablers, criteria, and attributes are defined and analyzed using this approach to answer the research questions developed, which are given in the upcoming paragraph.

The study focuses on answering the below questions:

RQ1: How the lean-sustainability practice level can be measured in a pottery manufacturing unit?

RQ2: What are the enablers, criteria, and attributes that influence the lean-sustainability practices in pottery manufacturing units?

RQ3: What are the weaker attributes of lean-sustainability practices in the case-pottery unit and how can these attributes be better addressed?

2. Literature Review

2.1 Lean practices and sustainability development

Pottery units are also small-scale manufacturing units that require restructuring and thereby bring in more profits with minimal waste to the three pillars– economy, environment, and society (Lu and Huang, 2019). It is proven that businesses can improve their efficiency and be more responsive to customers with the adoption of lean and sustainability practices. Industries are becoming more competitive, and consumers demand the products at the right time with the right quality; otherwise, the organization may lose its business, which can be catastrophic.

Using a case study, it is proven that lean and sustainability practices do make the business more efficient and that they eliminate non-value-added activities. The Pottery enterprises in India were chosen for the research and the results indicated that sustainable practices do impact positively on the three pillars – the economy, environment, and society- with the adoption of lean practices.

However, it is also noted that lean research has the drawback of not identifying, proving, and addressing the impact on long-term sustainability (Minh and Kien,2021). Lean manufacturing is adopted in the ceramic industry and it is proven that defects, waste, waiting time, processing time, inventory, and space are considerably reduced in the organization (Kleszcz et al. 2019; Sangwan et al. 2014). A value stream map (VSM) served as the initial point to identify waste in the enterprise. VSM assists in identifying the overall process and its wastes, which allows us to provide the necessary implementations in the specified or entire processes. Bhamu et.al., (2020) applied VSM in ceramic industry and their results showed that waste, processing time, waiting time, inventory, and labor were significantly decreased, and it also implies that lean implementation can be used to make other semi-process industries more organized (Bhamu et.al.,2020). The paper strengthens the importance of the adoption of lean manufacturing in the pottery industry as the method can help the industry be more organized with minimal waste and better processing.

2.2 Green Lean manufacturing in small scale industries

Today's world is so dynamic that an enormous amount of energy is required to run an industry. In such a highly dynamic environment, practicing Green Lean and sustainable practices is of real importance. The energy utilization and resources should be optimum and the practices should be in a sustainable manner. A case study is taken to demonstrate how the practices are done in a small-scale industry, which increases the product value as well as the sustainability of the industry (Nallusamy et al. 2015). However, researchers indicate that there is a poor adoption of lean among small and medium-sized enterprises and that this can be addressed to make the industries into better-organized ones. According to Alkhoraif et al. (2019) a major source of concern is a lack of knowledge in implementing lean systems. The first kind of research was done to understand the integration of green and lean practices for sustainable business practices and it was aimed at removing the barriers in the manufacturing sectors (Singh et al.,2022). The main hindrances in the manufacturing environment are considered material, technological, organizational, individual, quality, and cultural barriers. The study revealed that reduction of lead times, proper quality control methods, use of advanced technologies, and innovation consistently are the best methods to prevent the barriers that happen in the manufacturing sector. Singh et al. (2022) suggests ranking these solutions so that managers can prioritize which to adopt first and which to deploy last. According to Nagi et al., (2017), sustainable implementations address certain key issues other than the environment such as workforce issues, supply chain issues, community contributions, and governance and ethics. Adopting these practices can help the institution be organized sustainably.

2.3 To reduce errors in the line

Certain research has been done to identify the possible implementation of Lean Six Sigma and to use it to reduce errors in the production line (Kannan, 2017; Lande et al., 2016). Many industries will require this adoption, and it is relevant for a small-scale pottery manufacturing unit. The various factors involved in the pottery unit can be related to the six sigma tools, and a better path can be devised for the manufacturing facility which can reduce wastage and unnecessary or unutilized resources.

Implementation of Lean Six Sigma can help to save money and provide better outputs for the organization. It can be applied to any industry and industry level training and adoption can be done to suit the processes (Saha,2018). Companies also need to focus on factors other than environmental sustainability because most sustainability has been misjudged and implemented with respect to environmental factors. However, in order to maximize profits in any organization, businesses must align themselves in the diverse area of sustainability (Nambiar, 2010). Also, it is interesting to note that companies that have adopted Lean practices in their organization have overcome the effects of the pandemic quickly and better adapted to the changing environment. According to Cekerevac et al., (2022) firms that have not adopted lean principles have experienced significant business challenges and losses.

2.4 Noted Research gaps

Although lean and sustainable implementations improve bottom-line performance, sufficient implementation steps are not performed. According to the results of the research, there are some research gaps in the adoption of lean and sustainable systems, including social performance not being widely explored, mathematical modeling to assess the impact, and how the firm's performance rises Hartini et al. (2015).

3. Research Methodology

3.1 Multi-grade fuzzy

The multi-grade fuzzy was used to develop the assessment framework in the manufacturing and service sectors (Vinodh and Aravindraj, 2015; Sridharan and Suresh, 2016; Ganesh and Suresh, 2016; Vinodh and Chintha, 2011; Vinodh, 2011; Vimal et al., 2015; Almutairi et al., 2019).

The study utilized multi-grade fuzzy to assess the lean-sustainability practices in the rural pottery industry. The current study begins with a literature review on lean practices in manufacturing and sustainable developments in lean implementation in manufacturing. A lean-sustainability practices assessment framework is proposed with two enablers, nine criteria, and twenty-seven attributes shown in Table 1.

Table 1. Conceptual model of lean-sustainability practices in the rural pottery industry

Enablers	Criteria	Attributes
Sustainability Enabler (LS1)	Sale and promotions (LS11)	Online advertisements and awareness creation (LS111) - Through Facebook ads, YouTube, etc. Today, a large fraction of educated people are in the online mode.
		Online sale agents (LS112)
		Offline advertisements (LS113) –Makes people aware of the products
		Educational institutions (LS114) – Educational institutions are the primary cultivators of product awareness and benefits.
		Events and functions (LS115) – Small stalls near the spots of prime events and functions help to make people aware of the product.
		Sell products to these institutions (LS116) – Using products by these officials in places where the public is present helps to create a sense of demand.
		Promote the products in the place where they are sold (LS117) – A small bunch of brochures with the products and their benefits is where these items are kept. No need for an additional employee.
	Sustainable Production process (LS12)	Source of power (LS121) – Green sources of energy such as solar can be used to power the production units.
		No plastics or complete green (LS122) – Even packaging for pottery products can be done using dried grass and a hard paper carton. This will cost less and also be able to promote the environment. It can create competitive differentiation.
		Employee welfares (LS123) – Losing potential employees will damage the industry.

Lean Enabler (LS2)	Readiness (LS21)	Employee readiness (LS211) – Employees should be ready for a change if required in the organization. In other words, they should be adaptable.
		Supplier readiness (LS212) – The supplier (clay) should be readily available with a shorter lead time.
	Raw materials (LS22)	Clay (LS221) – Acquiring clay at a competitive price.
		Quality (LS222) – The quality of the clay is important.
	Machinery (LS23)	Equipment (LS231) – Machinery for molding the clay into pots.
		The furnace (LS232) – A furnace is used to heat the molded pots in order to give them strength.
	Labour (LS24)	Daily wage workers (LS241) – Costs to support them.
		Their unanticipated expenses (LS242) – Any medical emergencies.
		Office staff on contract (LS243)- The people who do the promotions and sales.
	Transportation (LS25)	Vehicle purchase (LS251) – Required vehicles have to be purchased (new or used) if required.
		Fuel charges (LS252) – The costs of fuel incurred while traveling.
	General (LS26)	Taxes (LS261) – Building, vehicle, and revenue taxes have to be paid.
		Insurance (LS262) – Since it is a business enterprise, the building, equipment, vehicle, and the relevant things should be insured, and it should be acquired at a competitive price with good coverage.
		Maintenance (LS263) – Equipment, vehicles, and buildings all require regular maintenance.
		Storage (LS264) – Storage costs have to be incurred for raw materials and finished products (can be leased or self-serve).
Unanticipated Factors (LS27)	Cash expenses (LS271) – COVID pandemic has taught us that cash has to be dispensed to employees to sustain their livelihood.	
	Total Revenue loss (LS272) – A total lockdown has made the enterprise shut down completely and it has generated zero revenue.	

4. Case Study

4.1 Case of the rural pottery industry

The Case is based on the rural pottery industry in India. The industry was run by traditional artisans who are skilled in the area of pottery manufacturing. However, the president and the secretary of the industry had concerns that there were many losses and that the industry was not ready for sudden market fluctuations. The COVID-19 pandemic left the industry with huge losses, and it impacted the daily wage workers who had no other sources of income. The infrastructure in the industry, such as the building, equipment, and furnace, required extensive maintenance and the source of income was not clear to meet these requirements.

Based on the study, the lean and sustainability enablers were identified and a multi-grade fuzzy approach was applied to find a lean-sustainability index. The lean-sustainability index is represented as L . It is the product of the overall assessment level of ratings based on each driver (R) and the overall weights (W) given by the experts. The equation for the lean-sustainability index is

$$L = W \times R \text{ (Anil and Suresh, 2020; Suresh et al., 2020; Ranjitha et al., 2022)}$$

The assessment has been divided into ten grades since the entire lean-sustainability index involves fuzzy determination. $H = \{10, 9, 8, 7, 6, 5, 4, 3, 2, 1\}$. 9-10 represents 'Extremely lean sustainable', 8-9 represents 'Very highly lean sustainable', 7-8 represents 'Highly lean sustainable', 6-7 represents 'Lean sustainable', 5-6 represents 'Moderately lean sustainable', 4-5 represents 'Low lean sustainable', 3-4 represents 'Very low lean sustainable', 2-3 represents 'Extremely low lean sustainable', 1-2 represents 'Not lean sustainable', and less than 1 represents 'Absolutely not lean sustainable'.

For the attribute's ratings, we used a questionnaire with a 10-point Likert scale, representing extremely high (10 points) to extremely low (1 point). The reverse scale is used to capture ratings for negative attributes (minimum is best). The weightage has been collected from five experts from various pottery units using a 10-point Likert scale that represents extremely high importance (10 points) to extremely low importance (1 point). The lean-sustainability practices ratings are collected from case rural pottery units' experts. It is captured in Table 2.

Table 2. Weights and performance ratings from experts

Enablers	Criteria	Attributes	R1	R2	R3	R4	R5	<i>W_{ijk}</i>	<i>W_{ij}</i>	<i>W</i>
LS1	LS11	LS111	9	10	9	10	10	0.1614	0.425	0.564
		LS112	3	8	7	7	8	0.1263		
		LS113	9	10	9	10	10	0.1017		
		LS114	10	10	10	10	10	0.1263		
		LS115	10	7	10	10	10	0.1614		
		LS116	10	10	10	10	10	0.1614		
		LS117	9	9	8	7	8	0.1614		
	LS12	LS121	6	6	5	5	5	0.3247	0.575	
		LS122	8	8	10	10	10	0.3504		
		LS123	8	8	5	9	9	0.3247		
LS2	LS21	LS211	5	4	4	2	1	0.4166	0.124	
		LS212	4	6	7	6	7	0.5833		
	LS22	LS221	7	7	8	9	10	0.4948	0.175	
		LS222	10	10	10	10	10	0.5051		
	LS23	LS231	6	6	6	9	10	0.4705	0.146	
		LS232	10	10	10	10	10	0.5294		
	LS24	LS241	8	8	7	6	6	0.3796	0.124	
		LS242	8	8	7	9	10	0.3425		
		LS243	9	9	10	10	8	0.2777		
	LS25	LS251	9	10	9	8	8	0.5696	0.171	
		LS252	4	4	3	5	5	0.4303		
	LS26	LS261	10	10	10	10	10	0.2793	0.138	
		LS262	10	8	9	10	10	0.2122		
		LS263	2	2	3	2	2	0.2458		
		LS264	8	10	10	10	10	0.2625		
	LS27	LS271	7	7	8	8	8	0.4625	0.12	
		LS272	10	10	10	10	10	0.5375		

4.2 First-Grade assessment

The first-grade assessment is done for the "Sale and promotions (LS11)" given below.

Weights concerning to "Sale and promotions" criterion is $W_{11} = [0.161, 0.126, 0.101, 0.126, 0.161, 0.161, 0.161]$

Assessment for the practice of "Sale and promotions" criterion is given below as

$$R_{11} = \begin{bmatrix} 9 & 10 & 9 & 10 & 10 \\ 3 & 8 & 7 & 7 & 8 \\ 9 & 10 & 9 & 10 & 10 \\ 10 & 10 & 10 & 10 & 10 \\ 10 & 7 & 10 & 10 & 10 \\ 10 & 10 & 10 & 10 & 10 \\ 9 & 9 & 8 & 7 & 8 \end{bmatrix}$$

Index concerning of "Sale and promotions" criterion is given by

$$L_{11} = W_{11} \times R_{11}$$

$$L_{11} = [8.691, 9.101, 9.035, 9.136, 9.424]$$

Similarly, the other criteria indexes are obtained below

- $L_{12} = [7.350, 7.350, 6.752, 8.051, 8.051]$
- $L_{21} = [4.416, 5.166, 5.75, 4.333, 4.5]$
- $L_{22} = [8.515, 8.515, 9.010, 9.505, 10]$
- $L_{23} = [8.117, 8.117, 8.117, 9.529, 10]$
- $L_{24} = [8.277, 8.277, 7.833, 8.138, 7.925]$
- $L_{25} = [6.848, 7.417, 6.417, 6.708, 6.708]$
- $L_{26} = [7.508, 7.608, 8.067, 8.033, 8.033]$
- $L_{27} = [8.612, 8.612, 9.075, 9.075, 9.075]$

4.3 Second-Grade assessment

The second-grade assessment for the enabler of “Sustainability enabler (LS1)” is given below as Weights concerning to “Sustainability enabler” given as $W_1 = [0.425, 0.575]$

Assessment of “Sustainability enabler” is given as below

$$L_1 = \begin{bmatrix} 8.691 & 9.101 & 9.035 & 9.136 & 9.424 \\ 7.350 & 7.350 & 6.752 & 8.051 & 8.051 \end{bmatrix}$$

Index concerning of “Sustainability” enabler is given by

$$L_1 = W_1 \times R_1$$

$$L_1 = [7.920, 8.094, 7.722, 8.512, 8.634]$$

Similarly, the other enabler index is obtained below

$$L_2 = [7.505, 7.710, 7.761, 7.961, 8.111]$$

4.4 Third-Grade assessment

The lean-sustainability assessment value of the case pottery unit has been calculated as follows

Complete weight $W = [0.564, 0.436]$

$$\text{Complete assessment vector } R = \begin{bmatrix} 7.920 & 8.094 & 7.722 & 8.512 & 8.634 \\ 7.505 & 7.710 & 7.761 & 7.961 & 8.111 \end{bmatrix}$$

Lean-sustainability index $L = W \times R$

$$L = [7.739, 7.927, 7.739, 8.272, 8.406]$$

The final lean-sustainability index is the average of $L = 8.01 \in (8 \text{ to } 9)$. \therefore ‘Very highly lean sustainable’

4.5 Importance Performance Analysis (IPA)

IPA is used for the classification of attributes based on their importance(weightage) and performance (rating) and it’s applied in various sectors (Tzeng and Chang, 2011; Vaishnavi and Suresh, 2021; Sreedharshini and Suresh, 2021). In IPA the x-axis is the performance rating of the attributes, and the y-axis is the importance. The mean of the x-axis is 8.03 and the mean of the y-axis is 8.16 as a perpendicular line in the given below Table 3.

Table 3. IPA analysis for lean-sustainability assessment of rural pottery industry

Importance ↑	10	Quadrant -I					Quadrant -II					LS222, LS261	
	9.7											LS221	
9.4											LS117	LS115	LS111, LS116, LS264
9.1											LS251		LS232
8.8		LS263											LS272
8.5							LS212						
8.2								LS241	LS231				LS122
7.9													
7.6							LS121			LS123, LS271	LS242	LS262	
7.3								LS112					LS114

	7					LS252												
	6.7																	
	6.4																	
	6.1			LS211													LS243	
	5.8	Quadrant -IV												Quadrant -III			LS113	
		2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
	Performance Rating →																	

Quadrant I (concentrate here): The attributes in the quadrant need to be paid attention to by the case-rural pottery unit’s manager to increase the lean-sustainability practice level of their operations (Subramanian and Suresh, 2022). The attributes are “supplier readiness and maintenance”.

Quadrant II (Keep up the good work): The attributes in the quadrant are needed to be maintained the same (Thomas and Suresh, 2022) and the attributes are “online advertisements and awareness creation, events and functions; sell products to these institutions; promoting the products where they are sold; clay, quality, the furnace; vehicle purchase; taxes; storage; total revenue loss”.

Quadrant III (Possible overkill): The attributes in this quadrant are of low importance but high performance (Suresh and Gopakumar, 2021). The performance of these attributes should be minimized. The attributes are “offline advertisements, educational institutions, no to plastics or complete green, their unanticipated expenses, office staff on contract, insurance”.

Quadrant IV (Low priority): The attributes in this quadrant are of low importance and low performance (Chacko et al., 2021). The attributes are “online sales agents, source of power, employee welfare, employee readiness, equipment, daily wage workers, fuel charges, cash expenses”.

5. Results and discussions

The suggestions for the improvement of weaker attributes are given in Table 4.

Table 4. Suggestions for weaker attributes

Weaker attributes	Suggestions for improvement
Supplier readiness	<ul style="list-style-type: none"> • Multiple sources of suppliers should be kept in contact. • The anticipation of flood-prone areas should be done and backup material should be available from other sources.
Maintenance	<ul style="list-style-type: none"> • Part of the revenue should always be kept in for maintenance as it can help the business run even during the crisis. • Equipment should be replaced at the required time to avoid quality issues and material wastage. • Infrastructure such as buildings should be periodically maintained to avoid operational issues. • Funding can be obtained with a proper revenue source from the local self-help groups or banks.

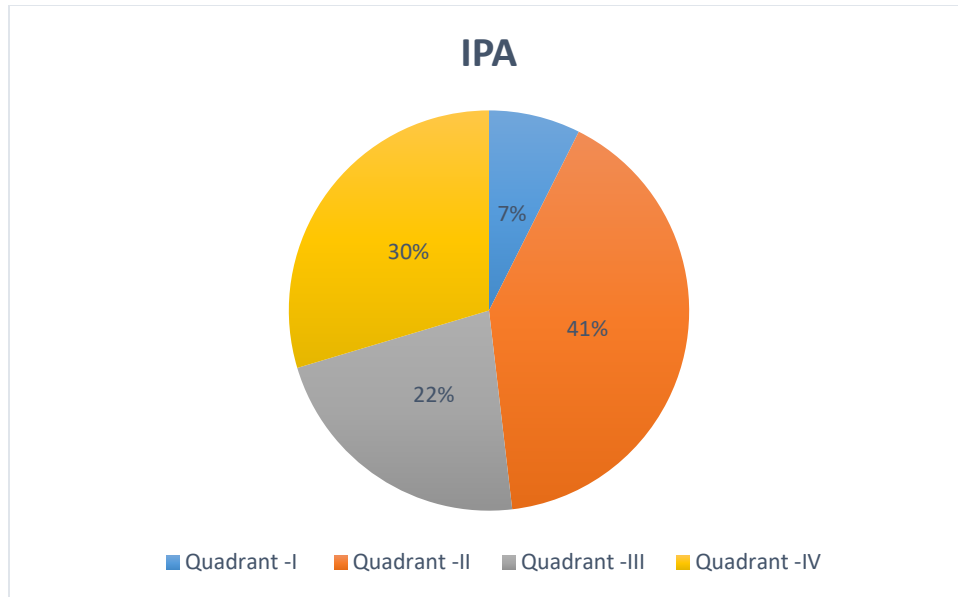


Figure 1. Graphical representation of IPA

Figure 1 shows the graphical representation of IPA. 7% of the factors in quadrant I need concentration and the management should take appropriate actions to improve it.

6. Practical Implication

The study understands and explains the various factors involved in the pottery manufacturing units and where the business concentration points have to happen to ensure the smooth flow of the daily operations. With the practical difficulties and bottlenecks experienced by the workers and management of the pottery unit, the study well identifies the lean and sustainability enablers in the manufacturing unit. The research identified two enablers, nine criteria, and twenty-seven attributes and rated the priority using the multi-grade fuzzy approach as explained. With the results now, the researchers and management can concentrate on the important requirements such as supplier readiness and maintenance and strive to improve these factors in the business model.

To improve the supplier readiness, the management can take key decisions and this will ensure the steady flow of raw materials into the unit even during a crisis time. Proper maintenance ensures the operational unit is running without a halt in the entire network.

Adoption and implementation of lean and sustainable practices in small-scale industries can help to improve revenue, reduce unanticipated outcomes and improve the lifestyle of the workers in the organization.

7. Conclusion

The present study focused on analyzing the current situations of the pottery manufacturing units and identifying the possibility of lean and sustainable implementation in the organization. Without lean and sustainable practices, the organization is identified to have many losses and is not capable of meeting the market fluctuations or demands. Small-scale industry units have generally not implemented lean and sustainability practices in their respective organizations and these organizations are stuck when unexpected events occur. However, these organizations provide a source of income for many daily wage workers and should not be put on hold because they may have an impact on the livelihood of many workers. Halting these types of industries can also mean losing many traditional products in which the employees are skilled.

In today's business world, lean-sustainability practices are of utmost importance to cope with the rising demands and increasing competition. While lean focuses on eliminating waste and improving efficiency, agile focuses on eliminating waste going to landfills to reduce environmental pollution. A manufacturing unit will have several sub-

units which are concentrated on their specific activities. These units will undoubtedly generate a large amount of both tangible and intangible waste over time. If lean is implemented, it can save by eliminating these wastes, especially the most precious ones such as time, materials, and energy. This can save on further costs incurred to the organization and ensure better revenue in the long run. Any manufacturing unit will produce some sort of waste that goes to landfills, and it is important in today's world that these landfills are reduced by the units to save the mother earth as well as to be on a competitive track with other industries. From the identified and prioritized criteria and enablers, it is clear that the industry can be better run with minimal changes and can improve the situations of the daily wage workers, increase revenue, reduce waste, and meet the fluctuating needs of the market with minimal inventory.

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