FARU FACULTY OF ARCHITECTURE RESEARCH UNIT UNIVERSITY OF MORATUWA, SRI LANKA
FARU 2023 - 16TH INTERNATIONAL RESEARCH CONFERENCE
www.faru.uom.lk
Empower Communities
December 2023

SUSTAINABLE 3R INITIATIVE PRACTICES IN THE SRI LANKAN LARGE-SCALE LEATHER FOOTWEAR INDUSTRY

SURIYARACHCHI D.P.[1]*, NUGAWELA C.T.[2] & DISSANAYAKE M.K.[3]
[1, 2, 3]University of Moratuwa, Moratuwa, Sri Lanka
[1]*dpsuriyarachchi06@gmail.com*, [2]*chathurika.tn@gmail.com*, [3]*melani@uom.lk*

Abstract: The leather footwear manufacturing process generates hazardous waste during production, which impacts sustainability. Due to this, industries tend to implement sustainable practices. This research focuses on identifying and recording the sustainable waste management practices of the large-scale leather footwear industry. Taking into account the industry complexity and requirements for doing an in-depth investigation, a single case study has been adopted. Working experience of 10 years in Industry and knowledge specific to the relevant production stage were key considerations in purposive sample selection in the study. Semi-structured interviews of 30-minute sessions are conducted in parallel to observational factory visits to improve the clarity of research findings. Interviews were conducted in Sinhala considering the workers' linguistic knowledge for data interpretation. The relationship between the independent and dependent variables is determined using the content analysis method. The current sustainable waste management practices were identified within the research study. The study revealed the findings on reducing, reusing, and recycling sustainable initiative practices of the large-scale leather footwear industry which can be adopted for small and medium-scale manufacturing sectors of the footwear industry in Sri Lanka.

Keywords: *Footwear Industry, 3R initiative practices, Leather footwear, Sustainability.*

1. Introduction

The relationship between humankind and the environment is at risk due to certain practices adopted by the industry. Since the Industrial Revolution, significant increases have been seen in the worldwide population. Industrialization in developing nations has a wide range of adverse social and environmental effects that are inappropriate for the survival of humanity. According to Song et al. (2000), during the entire leather production process, from the preparation of leather to the finished product, highly contaminated liquid waste, dangerous chemicals, waste materials, and odorous pollutants are released into the environment. It is a continuous challenge for the industrial sector to address and achieve sustainability while sticking to sustainable strategies and sustaining the demand for the brand image. However, due to the high cost of material and sustainability impacts that occur from leather processing to production, it is crucial to concentrate on the minimization of material wastage and maximization of material utilization. According to Jadhav and Jadhav (2020), reduce, reuse, and recycle waste management practices are (3R initiatives) involved in minimizing sustainability impacts while achieving the minimization of material wastage within the footwear industry. Sri Lankan leather footwear is a highly valuable manufacturing industry that strengthens Sri Lanka's export earnings. Around 20,000 people are employed directly and indirectly by this sector in Sri Lanka. These comprise 3000 small-scale manufacturers, 30 medium-sized firms, and 10 large exporters (Footwear Industry in Sri Lanka - EDB Sri Lanka, n.d.). The majority of currently available research has only focused on the overall production process of the footwear industry without properly documenting leather footwear manufacturing. Nevertheless, they fail to explain the sustainability practices of leather footwear manufacturing. The possibility of looking into this knowledge gap and the lack of related studies locally was considered in the selection of the research problem for this study. Ignorance of looking into the matter would create a significant negative influence on the environment and increase industrial waste generation. Considering the importance of the selected research area, this study focuses on identifying and recording the current sustainable practices of reduce, reuse, and recycle (3R) initiative contribution towards sustainable waste management within the local leather footwear industry to improve the footwear manufacturing sector in Sri Lanka.

2. Literature Review

2.1. SUSTAINABLE WASTE MANAGEMENT PRACTICES AND REDUCE, REUSE AND RECYCLE INITIATIVES

As sated by Gertsakis and Helen Lewis(2013)the environmental movement began to criticize the practice of disposal-

*Corresponding author: Tel: +94 768025102 Email Address: dpsuriyarachchi06@gmail.com
DOI: https://doi.org/10.31705/FARU.2023.16

based waste management in the 1970s, which is when the hierarchy of waste management first emerged. They contended that instead of viewing "rubbish" as a homogenous mass that should be buried, it was made up of many materials that should be handled in various ways, some of which should not be generated, some of which should be reused, and some of which should be recycled or composted.

The Victorian Environment Protection Act specifies that wastes should be managed in line with the following order of preference: avoidance, reuse, recycling, and recovery of energy, treatment, containment, and disposal. This hierarchy is engrained in Victoria. The primary organization for creating and facilitating plans that aid in operationalizing the hierarchy with respect to solid waste is EcoRecycle Victoria, with its numerous business, governmental, and community activities. Their work has had a significant impact on shifting some business sectors and organizations away from the simple transportation and management of garbage and toward resource recovery and related market development initiatives.

As mentioned by Jadhav and Jadhav (2020), reduce, reuse, and recycle initiatives represent the waste management hierarchy. It is considered an efficient way of achieving waste management within the industry. Industries tend to practice this concept to manage waste generation considering following sustainable industrial laws.

Waste hierarchy has been contemplated in the international and national regulations, although there are no indicators for its implementation. The existing indicators were intended to quantify the performance of specific waste operations: source separate collection and recovery and recycling rates, with targets defined in European Union waste directives. There has been a waste hierarchy principle for around 40 years. The idea was started in the United States by the private company company 3M (Overcash, 2002), and it was introduced in Europe by the Dutch politician Ad Lansink, that put forth the idea in the Dutch Parliament in 1979 (Parto et al., 2007). This is stated by van Ewijk and Stegemann (2016).

The Waste Framework Directive (European Parliament and Council, 2008) introduced the waste hierarchy principle, which was later incorporated into national laws of Member States of the European Union (EU). According to the European WFD, the hierarchy of waste management practices includes prevention, preparation for reuse, recycling, alternative extraction (including energy recovery), and disposal. As mentioned by Pires (2019) the present waste management directives of the European Union seek to encourage waste prevention and the implementation of a hierarchy of waste management practices, including preparation for reuse, recycling, alternative recovery, and disposal.

As stated by European Commission (2017) the "3R" principle, which stands for reducing, reducing, and recycling, is at the heart of green industrial design. Waste reduction is an effective approach for lowering the amount of trash that industry operations generate. According to van Rensburg et al., (2020) reduced waste production during the design phase could potentially be accomplished by skill of workers and design techniques. 3R waste management practices are widely utilising the industry practices through the global application since years back. It stands as a waste management concept to minimise industrial pollution and make sustainable production.

As explained by Staikos and Rahimifard(2007) industries adopted with latest cutting edge technologies focusing on waste reduction and efficient production in footwear industry. If the footwear industry recognizes the benefits of being "green" in terms of competitive advantage, the industry will adopt design principles and make sustainability a key component of its strategy, including innovative methods based on the 3Rs to reduce sustainability impacts (Marques et al., 2017).

The 3Rs rule, or circular economy, is primarily represented in the literature through these three primary acts (Ghisellini et al., 2016). As noted by Zhang et al. (2022) the waste hierarchy is closely tied to the R-based circular economy ideas. Both the waste hierarchy and the circular economy take into account the entire life cycle of a product, including the pre-use, use, and post-use phases.

The circular economy and the waste hierarchy have both developed over time to stress the design and usage of a product before it becomes waste. Thus, it is clear that the circular economy and the waste hierarchy share a common mind-set that aims to manage trash by rethinking, redesigning, and repurposing to increase a product's resource effectiveness and decrease the formation and negative effects of waste.

3. Methodology

Based on the Saunders et al, (2013) research onion, in the research methodology has selected the qualitative method to conduct an in-depth investigation of the industry surrounding. As stated by (Saunders & Lewis, 2012) qualitative methodological choice facilitates making observations along with non-numerical or non-statistical methods, this method used to acquire in-depth contextual awareness. Considering the requirement of in depth investigations the case study search strategy was selected. With the complex surrounding and considering the production variations with the footwear manufacturing scale, has selected single case study strategy to conduct in depth investigate on the research area. Before the data collection phase started the researcher has conducted preliminary studies to get better

understanding on footwear industry and to improve the clarity of the research questionnaire. The purposive sampling method was selected to identify the interviewing participants to collect data based on each research question taken into consideration. The data collection phase comprised with 30 minutes semi structured interviews and parallel observation based factory visits. Collected data were transcribed and analysed based on qualitative content analysis.

3.1. THE CONCEPTUAL FRAMEWORK

The conceptual framework (shown in Figure 1) developed, enables a better understanding of the complex industrial process that offers comprehensive qualitative research in depth understanding for the following research questions. (1) What are the 3R sustainability initiative practices within the global footwear industry? (2) How does the leather waste produce at each stage of the production process within the large-scale local Industry practices? (3) How does the large-scale local leather footwear industry practice Reduce, Reuse, and Recycle sustainability initiatives throughout the production process at each stage? (4) What are the future initiatives of 3R sustainability strategies within the large-scale local Leather footwear Industry?

Framework is generated based on the research questions the existing literature. Based on the support provided by the existing literature and the identified Independent and Dependent variables, the moderator variables were identified.

The 3R initiatives are directly involves with the waste management within industries that attempt minimizing the waste generation considering industrial policies into account. Considering this fact, the independent and dependent variables were defined on investigating the current practices of large scale leather footwear industry. Typically, moderate variables build the foundation for connections between independent and dependent variables, thereby based on the referred literature it represents the Skill and experience of workers, working techniques and machinery involvements.

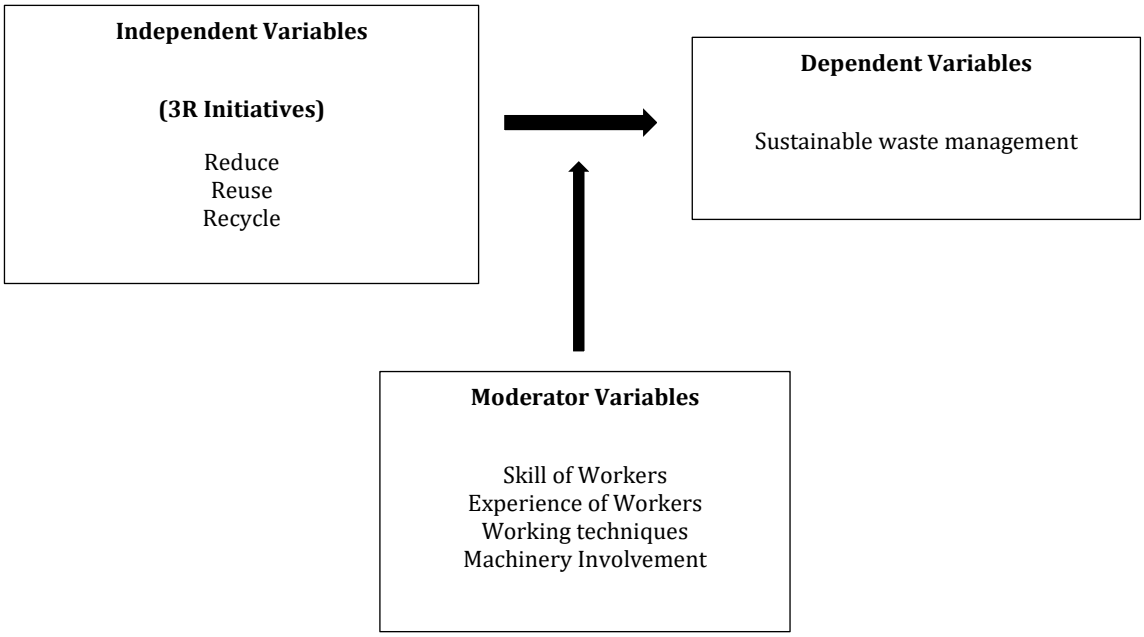


Figure 1. The Conceptual framework (Source: Author)

3.2 RESEARCH STRUCTURE AND PLAN

The phases of the research study are comprised of Research Planning, Literature reviewing, Data collection, Data analyzing and research Conclusion. Data collection methods, analyzing technics and sampling strategies were defined considering the qualitative research techniques and procedures focused on finding out answers for research questions. As depicted in Figure 2, shows the research plan study phases and data collection methods and analyzing procedures to acquire research conclusions.

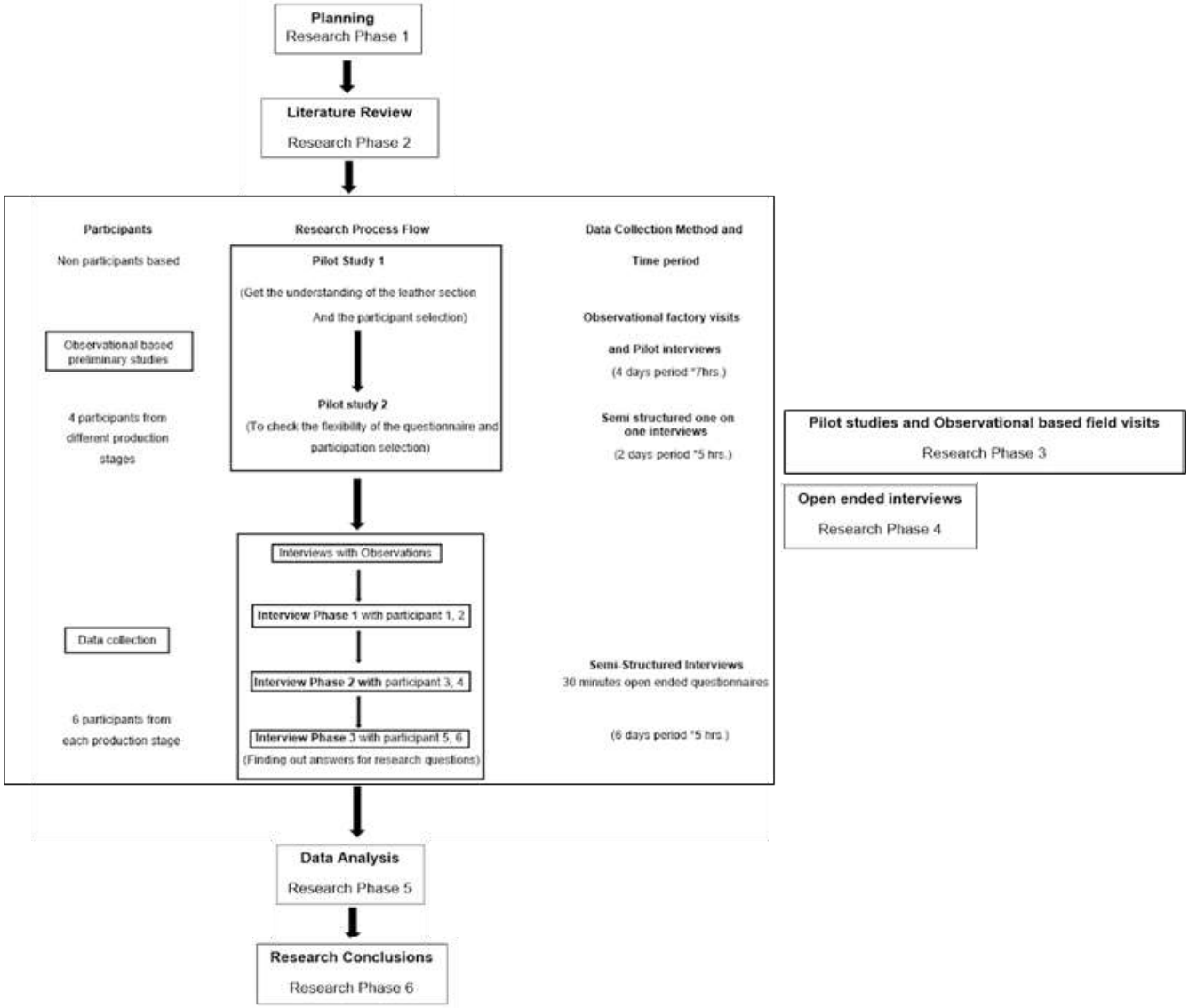


Figure 2. Research plan and the Structure *(Source: Author)*

3.3. SAMPLING PROCEDURE AND PARTICIPANT SELECTION

Table 1. Sampling procedure and Participant selection
Source: Author

Question	Participants	Interviewer (**I**)
RQ2: How does the leather waste produce at each stage of the production process within the large-scale local Industry practices? **RQ3:** How does the large-scale local leather footwear industry practice the Reduce, Reuse, and Recycle sustainability initiatives throughout the production process at each stage?	Research and Development Department Design department Costing department, Leather Section Production Planning Department **(6 Interviewers)**	**I1-**Head of the Department Research and Development **I2-**Head of the department Production Planning **I3-**Senior Designer **I4-**Head of the Leather section **I5-**Head of the Costing department **I6-**Assistant manager Research and Development

RQ 4: What are the future initiatives of 3R sustainability strategies within the large-scale local Leather footwear Industry?	Research and Development Department Compounding department, Production Planning Department **(4 Interviewers)**	**I1-**Head of the Department Research and Development **I2-**Assistant manager Research and Development **I3-**Head of the department Production Planning **I4-**Chief development officer

Determining the particular industrial knowledge-based procedures and the expertise's experience in the study, semi-structured interviews were conducted, in order to obtain the purposive sample participant's experience in the relevant production stage. It's essential to precisely identify and collect data through semi-structured interviews and observational-based industry visits due to the intricate nature of the surrounding business. Considering the complexity of the industry, purposely selected sample participants were identified with the findings of preliminary study. Based on the research questions and the knowledge specify to the research stage the interviewers were selected separately for the interviews. Semi-structured interviews were conducted to elicit the purposive sample participant's experience on a minimum of 10-year industry working experience and knowledge relevant to the production stage practices. The selected participants were interviewed separately based on 3 interview phases with 30-minute sessions taking into account, the industrial background and the tough working schedule within the industry. Available time periods of the interviewees were considered prior conducting interviews in order to prevent disruption to the industry workflow.

3.4. DATA COLLECTION

The research focused on finding out reduce, reuse, and recycle sustainable practices of large-scale leather footwear industry. In the first pilot study, it was suggested to have an extensive understanding of the industrial surrounding in order to become more acquainted with the various kinds of machinery and working conditions encountered inside. Investigations were accordingly focused on the manufacturing of leather footwear. After acquiring more comfortable with and knowledge about leather production during the second part of the pilot study, selected interviewers were given pre-made semi-structured interview questionnaires to respond in order to determine the reliability of the research questions. This procedure aided in making study questions more accurate to the findings gathered. Additionally, photographs of the various production stages were collected for additional observations. Given the complexity of the workplace, it is crucial to perform observation-based data collecting to acquire an extensive understanding of the procedure without being constrained by findings from semi-structured question-based research. The semi-structured interviews were conducted parallel with these observational studies. Based on in-depth knowledge of the sector and ten years of experience, participants in the semi-structured interviews were chosen. As the interviews were semi-structured, the researcher was able to bring up carefully planned questions. All interviews were carried out in the workplace at the convenience of the employees.

4. The procedure of data analysis

By applying the content analysis method to examine the data from semi-structured interviews and observations, the study questions were determined. Data was transcribed based on production stages, segmented, and narrowed down to small categories. Initial codes were created based on summarized explanations, and focused codes were identified.

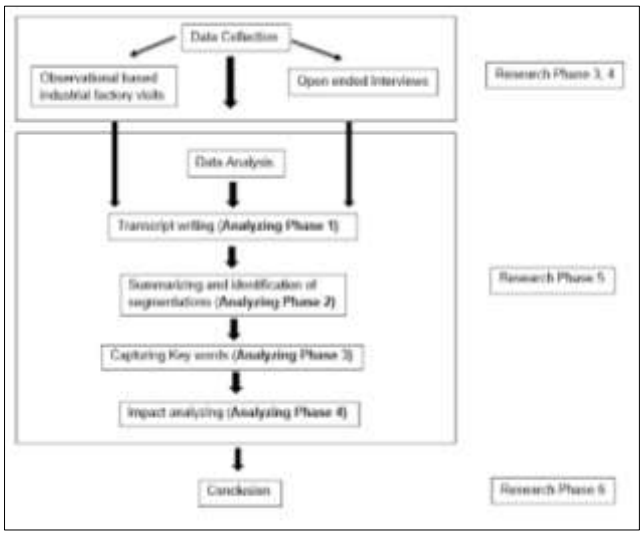


Figure 3. Data analysis Flow Chart *(Source: Author)*

Table 2 . Primary analysis *Source: Author*

Immediate Analysis	Initial Codes
Waste converting into other product lines. Consider the environmental impact while disposing of the waste. Continuously testing and finding effective solutions for industrial wastage. Machine operations can minimize human errors. The injection molding technology. Expertise members in machine and automation	Burning Impact Machinery involvement New solutions Latest technology Skilled Workers

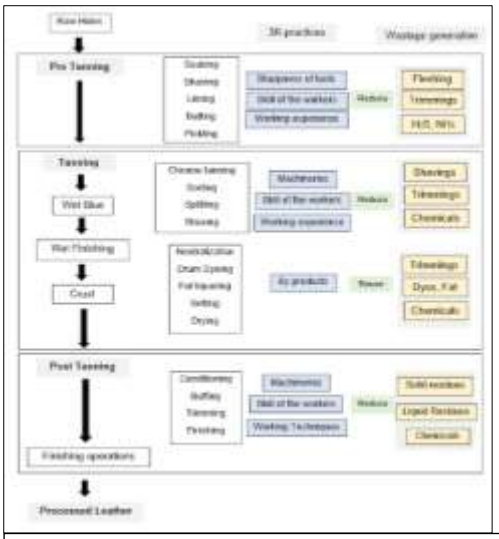
Table 3. Secondary analysis

Initial Codes	**Focused Codes**	**Reduce**	**Reuse**	**Recycle**
Burning Impact	Harmful	-	-	-
Machinery involvement	Machinery	+	+	+
New solutions	Innovations	+	+	+
Latest technology	Technology	+	+	+
Skilled Workers	Skill	+	+	+

The analysis procedure comprised three main stages. The initial codes were derived from interview transcriptions. Then carried out with initial coding. Generated focused codes out of the themes. Started with identifying the positive, negative and neutral impact to the independent and dependent relationship.

Both the conclusions from the observation data and the interviews followed distinct analyses. The relationship between the independent variable (IV) and to dependent variable (DV) was investigated by considering the sustainability impact. The relationship indicated the current impact at each production stage towards the 3R sustainability initiatives. With the analysis of the production stage, if interaction positively impacts the 3R initiatives then a plus mark (+) is inserted in front of the variable. If the interaction impacts negatively the variable, a minus mark (-) is inserted into the specific initiative. A minus mark (-) indicates a neutral impact.

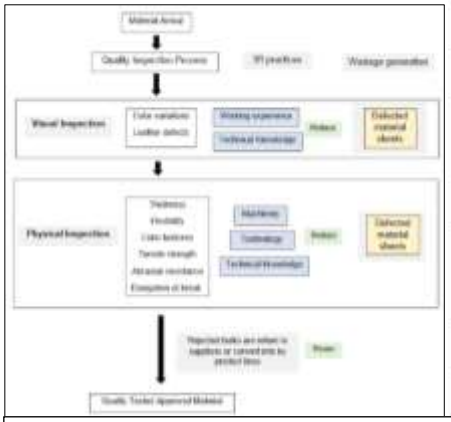
5. Final analysis



Before the production	Summarized Explanation	Initial Codes	Focused Codes	Re-duce	Reuse	Recycle
Leather Processing Stage	Skill of the Workers	Working Skill	Skill	+	+	+
	Manmade Leather defect	Defects	Human error	-	-	0
	Highly value the Working practice	Continuous practice	Experience	+	+	+
	Tool handling and Manual techniques	Manual Techniques	Techniques	+	+	+
	Newly updated machine operations	Latest machine	Machinery	+	+	0
	Machinery based operation errors	Operational errors	Machine errors	-	-	0
	Sharp tools and smooth processing	Smooth handling	Tools	+	+	0
	Less concentrated storing facilities	Effective storing	Facilities	-	-	0

Leather Processing
Generated focused codes, the 'working skill', 'Experience', and 'Techniques' directly impact the recycling capability in positive. 'Skill', 'Experience', 'Techniques', 'Machinery', and 'Facilities' positively impact the Reduce initiative by minimizing wastage generation. Storing 'facilities', 'machine errors' and 'human errors' negatively impact waste reduction and reuse capabilities and neutral impact on recycling initiative.

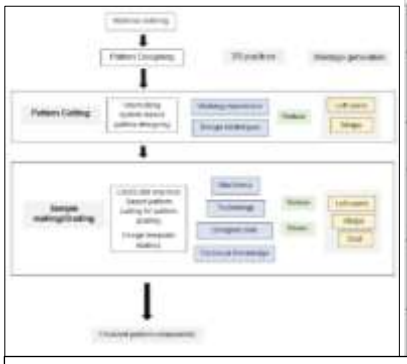
Figure 4. Analysis of Leather processing practices *(Source: Author)*



Before the production	Summarized Explanation	Initial Codes	Focused Codes	Reduce	Reuse	Recycle
Quality Checking	Visual inspection techniques	Manual Techniques	Techniques	+	+	0
	Physical Inspection technology	Machine techniques	Techniques	+	+	0
	Inspection Officers	Workers	Technical Knowledge	+	+	0
	Rejected hides are converting to another production line	Conversion	Byproducts	+	+	0
	Inspection matters	Manual errors	Human errors	-	-	0
	Lab testing faults	Testing errors	Machine errors	-	-	0

Leather Quality checking
'Techniques', 'Technical knowledge', and 'Byproducts' generated codes indicate the positive impact on reduce and reuse initiatives. The manual techniques, Machine techniques, inspection-related technical knowledge of the workers, waste conversion, and byproducts are the main practices that positively impact. Machine errors and human errors negatively impact waste reduction and reuse capabilities and neutral impact on recycling initiative.

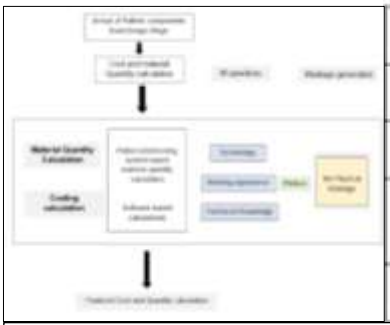
Figure 5. Analysis of Leather quality checking practices *(Source: Author)*



Before the production	Summarized Explanation	Initial Codes	Focused Codes	Reduce	Reuse	Recycle
Design stage	Cutting template making for the specific pattern components	Manual Techniques	Techniques	+	0	0
	Skilled designers	Workers	Skill	+	+	0
	Pattern cutting techniques are highly needed	Manual Techniques	Techniques	+	+	0
	Practice helps in improving the pattern cutting	Continuous practice	Experience	+	+	0
	Software based Pattern grading	Technical applications	Technology	+	+	0

Designing stage
Generated codes, 'Techniques', 'Skill', 'Experience', and 'Technology' directly impact waste reduction positively. The skill of the Designer, Pattern cutting techniques, Working experience, and technology-based practices are the main key factors that directly affect the initiatives. 'Human errors' and 'Machine errors' negatively impact waste reduction and reuse capabilities within the stage and neutral impact on recycling initiatives.

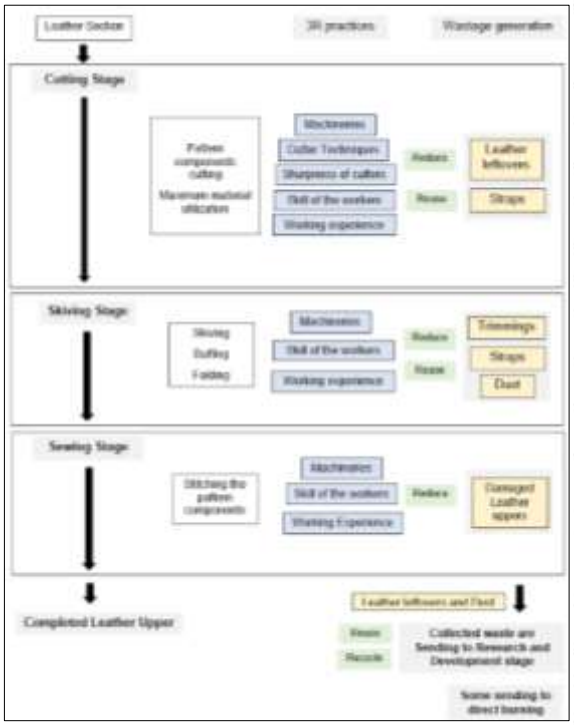
Figure 6. Analysis of design stage practices *(Source: Author)*



Summarized Explanation	Initial Codes	Focused Codes	Reduce	Reuse	Recycle
Software based calculations	Software	Technology	+	0	0
Technical team involvement	Workers	Skill	+	+	0
Interlocking system based material calculation	Technical calculations	Technical Knowledge	+	+	0
Interlocking pattern cutting technique	Manual technique	Technique	+	+	0

Costing stage
'Technology', 'Skill', 'Technical Knowledge', and 'Technique' such as generated codes positively impact waste reduction and Reuse initiatives. Software calculation faults and manual calculation faults based on focused codes indicate the negative impact of reducing and reuse initiatives. Each identified focused code has a neutral impact on recycling initiatives.

Figure 7. Analysis of costing stage practices (Source: Author)

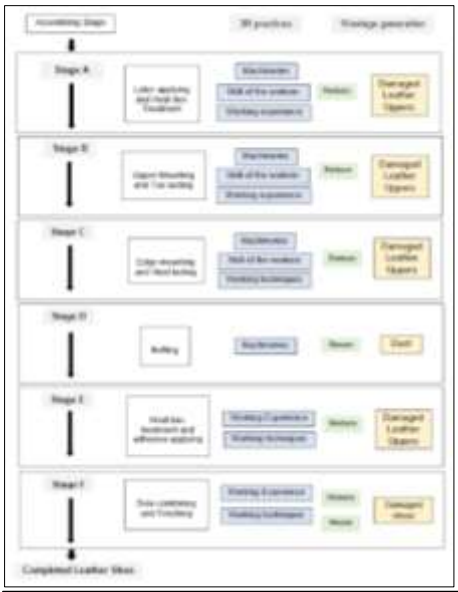


Before the production	Summarized Explanation	Initial Codes	Focused Codes	Reduce	Re use	Recycle
Cutting stage	Technical Cutter handling	Manual technique	Technique	+	+	+
	Smooth cutter handling	Handling techniques	Technical knowledge	+	+	+
	Efficient machine operations	Handling operations	Technical knowledge	+	+	+
	Experienced workers	Getting Practice	Experience	+	+	0
	Machinery faults	Handling operations	Machinery errors	-	-	-
	Cutter uses faults	Manual errors	Human error	-	-	-
Skiving stage	Smooth machinery operations	Machine operations	Machinery	+	+	+
	Efficient working practice	Getting Practice	Experience	+	+	0
	Skiving skill	Technical practice	Technical knowledge	+	+	0
	Machinery breakdowns	Machine operations	Machine errors	-	-	-
	Working pressure faults	Manual errors	Human errors	-	-	-
Sewing stage	Smooth machinery handling	Machine operations	Technical knowledge	+	0	0
	Quick and efficient working	Getting Practice	Experience	+	0	0
	Machinery involved defects	Machine operations Manual errors	Machine errors	-	-	0
	Working flow issues	Manual errors	Human errors	-	-	-
	Incorrect instruction follow ups	Manual errors	Human errors	-	-	-

Leather section

'Technical Knowledge' and 'Experience' indicated the positive impact. 'Human error' and 'machinery error' codes are representing the negative impact. 'Experience' and 'Technical knowledge' impact reuse and recycling initiatives in a neutral. 'Machinery', 'Experience', and 'technical knowledge' positivity towards the reuse initiative. 'Machinery 'and 'human error' codes indicated a negative impact. 'Experience' and 'Technical knowledge' codes represent neutral impact of the recycling initiative.

Figure 8. Analysis of Leather section practices *(Source: Author)*



Summarized Explanation	Initial Codes	Focused Codes	Reduce	Re use	Recycle
Skill of the workers is highly needed	Working Skill	Skill	+	+	0
Machinery based technical practice	Technical Practice	Technical Skill	+	+	0
Efficient production with experience	Effective practice	Experience	+	+	0
Coordination between sub sections	Effective practice	Technical Knowledge	+	+	0
Machinery handling practice	Technical knowledge	Technical knowledge	+	+	0
Technical practices	Technical Skill	Technical Skill	+	+	0
Skill of the workers	Working Skill	Skill	+	+	0
Technical based machinery breakdowns	Machine faults	Machine errors	-	-	0
Continuous attention and practice	Working experience	Experience	+	+	0
Manual assembling faults	Working errors	Human errors	-	-	0
Follow up the instruction guide	Capacity of work	Technical Knowledge	+	+	0

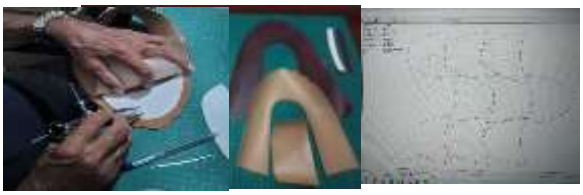
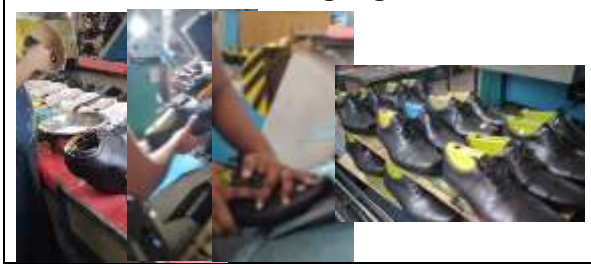
Assembling section stage

'Technical skill', 'Experience', and 'Technical knowledge' codes positively involved in reduce and reuse initiatives and neutral impact on recycling initiative. It highlights the importance of the technical knowledge of the workers and their experience towards waste minimization and effective material use. Generating machine errors and the errors that occurred negatively impact reduce and reuse initiatives.

Figure 9. Analysis of assembling section practices (Source: Author)

6. Discussion and research findings

Table 4. Research findings and suggestions *(Source: Author)*

Production stage	Reduce, reuse, and recycle practices
Leather processing stage 	• Skilled workers are experts in leather flying and it minimizes leather defects. • Flaying techniques and processing techniques maximize the leather-cutting value. • If can minimize leather branding can able to minimize a lot of leather waste during the pre-tanning process. • The storage conditions and transportation modes impact the quality of the leather with the natural surface structure.
Design and costing stage 	• The designers' expertise and experience enable them to utilize pattern-cutting techniques to reduce and manage material waste. • By using this technique, material waste is reduced and leftovers can be reused based on the designer's skills. • Interlocking focused pattern cutting to improve the cutting value. • Software-based waste reduction approaches are directly impacted by patterns interlocking system designs and material quantity calculation. • The primary factor that directly impacts to decrease in the amount of material waste is the interlocking ability of the pattern component designs.
Leather cutting stage 	• Utilizing efficient cutting methods increases the leather's cutting value. • The current production process must be improved to acquire the necessary understanding and expertise to the most recent levels, the industry could arrange the necessary training sessions and machinery-based technical knowledge-gaining sessions with specialized experienced parties.
Leather skiving stage 	• Workers' skills, machinery handling, and technical abilities are crucial in leather skiving due to the high price value of the material. • To prevent mistakes in leather uppers, the patience and skill of the workers are highly important. • If any skiving errors are made directly, it ends up as a waste which causes a huge material wastage during mass production. • Skiving leftovers utilizing leather recycling and making inks out of it.
Sewing stage 	• By setting up knowledge-gaining sessions and offering the necessary technical guidance, sewing mistakes can be reduced. • If any errors occur during sewing it directly impacts the assembling process and causes a lot of product defects.
Assembling stage 	• With the assistance of the technical team, keep the machinery updated by giving it greater technical attention. • The industry can continuously monitor the progress of the workforce through quality inspection processes to reduce human error.

7. Conclusions

The research study focused on identifying sustainable waste management practices in the large-scale leather footwear industry. The involvement of reduce, reuse, and recycle sustainable initiatives was identified throughout

each stage of the production process within the industry practices into consideration. The study reveals that each stage of the production process involves producing waste during leather footwear manufacturing. The production of material waste in the leather footwear industry starts with the preparation of the leather and continues through to the finished item. Each industrial process contributes to waste generation and the present usage of the initiative's best practices for reducing, reusing, and recycling are documented in the study.

The research findings, study revealed that the leather processing stage practices majorly involved in waste generation in leather footwear manufacturing, and the assembling stage involved the least waste produced. Based on the interview findings pre-tanning, tanning, and post-tanning leather processing practices are involved in the generation of solid and liquid wastes. The leather processing stage discharges highly polluted wastewater which contains toxic chemicals and, through the manufacturing stages produces leather trims and dust.

Processing stage, quality checking stage, designing stage, leather section cutting, skiving, sewing practices, and assembling stage practices are both adopted waste reduction and reuse practices during production. The costing stage practices only work on material waste reduction. The recycling practices are only initiated by the research and development department within the industry.

The study demonstrated that the leather defects majorly lead to minimizing the cutting value of leather material while making the material end up as a high waste outcome. The difficulty of leather processing and the high value of leather material, it is crucial to maintain sustainable production by saving material cutting value during leather processing and have to continue with minimum waste generation throughout the production process once entered into the manufacturing stages as documented in the research.

Based on the research findings leather cutting stage is another crucial stage that requires skilled cutter men and technical skills of cutter handling experiences to minimize wastage generation. According to the research findings designer skills, and pattern-cutting techniques are other key factors that impact waste management within the industry. Based on the interview data study revealed that large incisions in the hide which are caused by flaying techniques and leather flaws result in leather defects and lower the leather cutting value by 60 to 70%. The practice of leather branding primarily reduces the ability of leather hide to manufacture high-quality leather and results in significant material waste during the processing stage as documented in the research findings.

With the derived coding of the final analysis, “Tools”, “Experience”, and “skill of workers”, “Manual, and machinery techniques”, “Facilities”, “Technology”, “Machinery”, “Technical knowledge”, and “Waste conversion” are identified as key practices which positively impacts the sustainable waste management. Generated codes, “Human errors” and “Machinery errors” negatively impact sustainable waste management as documented in the analysis. Therefore, the derived codes in this study show the positive and negative impact on sustainable waste management as moderator variables based on the current practice of reduce, reuse, and recycle initiatives into consideration.

As demonstrated by the research findings, the large-scale local leather footwear industry has placed an intense focus on actions that promote sustainable waste management through reduction and reuse initiatives. The recycling initiatives are at the experimenting level and constantly being tested. In the future, projects will concentrate on using technology to achieve effective solutions.

8. References

Ahn, S. H., & Lee, J. Y. (2018). Re-Envisioning Material Circulation and Designing Process in Upcycling Design Product Life Cycle. *Archives of Design Research*, *31*(4), 5–20. https://doi.org/10.15187/adr.2018.11.31.4.5

Alaoui, M. A., Ezzine, M., & Azzi, M. (2012). Applying the principles of sustainable development in the leather industry in Morocco: tannery case. *International Journal of Environment and Sustainable Development*, *11*(2), 180. https://doi.org/10.1504/ijesd.2012.049194

Amrina, U., & Elisa, N. (2019). Application Of Sustainable Productivity Management In Footwear Companies By Green Manufacturing Approach. *Sainstech: Jurnal Penelitian Dan Pengkajian Sains Dan Teknologi*, *29*(2). https://doi.org/10.37277/stch.v29i2.336

Chen, K. W., Lin, L. C., & Lee, W. S. (2014). Analyzing the Carbon Footprint of the Finished Bovine Leather: A Case Study of Aniline Leather. *Energy Procedia*, *61*, 1063–1066. https://doi.org/10.1016/j.egypro.2014.11.1023

Gupta, S., Gupta, S., Dhamija, P., & Bag, S. (2018, April 3). Sustainability strategies in the Indian leather industry: an empirical analysis. *Benchmarking: An International Journal*, *25*(3), 797–814. https://doi.org/10.1108/bij- 06-2017-0140

Jadhav, N. C., & Jadhav, A. C. (2020). Waste and 3R’s in footwear and leather sectors. *Leather and footwear sustainability: Manufacturing, supply chain, and product level issues*, 261-293.

Manel, D. P. (2012). Technology Problems in Small and Medium Scale Enterprises in Sri Lanka: With Reference to Footwear and Leather Products Manufacturing Sector in the Western Province. In *Proceedings of International Conference on Humanities and Social Sciences* (Vol. 1).

Marques, A., Guedes, G., & Ferreira, F. (2017). Leather wastes in the Portuguese footwear industry: new framework according design principles and circular economy. *Procedia Engineering*, *200*, 303–308. https://doi.org/10.1016/j.proeng.2017.07.043

Moktadir, M. A., Mahmud, Y., Banaitis, A., Sarder, T., & Khan, M. R. (2021). Key Performance Indicators for Adopting Sustainability Practices in Footwear Supply Chains. *E+M Ekonomie a Management*, *24*(1), 197–213. https://doi.org/10.15240/tul/001/2021-1-013

Moktadir, M. A., Rahman, T., Ali, S. M., Nahar, N., & Paul, S. K. (2019). Examining barriers to reverse logistics practices in the leather footwear industry. *Annals of Operations Research*, *293*(2), 715–746. https://doi.org/10.1007/s10479-019-03449-y

Moktadir, M. A., Rahman, T., Rahman, M. H., Ali, S. M., & Paul, S. K. (2018). Drivers to sustainable manufacturing practices and circular economy: A perspective of leather industries in Bangladesh. *Journal of Cleaner Production*, *174*, 1366-