A Comprehensive Analysis and Ranking of Barriers to implement lean practices in chemical management of Leather Tanning Industries in Bangladesh.

Md. Mahfujul Haq
Research Assistant, Susleather Project
Department of Mechanical and Production Engineering
Ahsanullah University of Science and Technology
Dhaka, Bangladesh
Email- mahfuzipe.buet@gmail.com

Prof. Dr. Mohammad Sarwar Morshed
Professor, Department of Mechanical and Production Engineering
Leader, Susleather Project
Ahsanullah University of Science and Technology
Dhaka, Bangladesh
Email- m.morshed.mpe@aust.edu

Mongsathowai Marma
Research Assistant, Susleather Project
Department of Mechanical and Production Engineering
Ahsanullah University of Science and Technology
Dhaka, Bangladesh
Email- babumarma077033@gmail.com

Dr. Abu Hamja
Assistant Professor, Department of Mechanical and Production Engineering
Deputy Leader, Susleather Project
Ahsanullah University of Science and Technology
Dhaka, Bangladesh
Email- abuhamja.mpe@aust.edu

Abstract

The leather tanning industry is essential to Bangladesh's economy, significantly boosting employment and economic growth in the country. More than a million Bangladeshis work in this sector, which provides chances for both skilled and unskilled labor.But the chemical management component of tanneries carries inherent hazards, hence existing approaches need to be reassessed and redesigned. However, there are significant obstacles to improving the tanneries' working conditions and productivity in the chemical management part. To develop productivity and safety, lean is an option that needs to be explored more widely in the tannery context. Through interviews with industry expertsand a careful evaluation of the body of current literature, this study has identified potential barriers to starting lean practices in the chemical management of the production floorAfter the literature review, the barriers are analyzed using the MCDM tool to rank them according to the collected data. The barriers will be ranked using the Best Worst method. In order to overcome these significant obstacles and enable the successful adoption of lean techniques for sustainable chemical management in Bangladeshi leather tanning, policymakers, tannery owners, and development organizations can benefit significantly from the information provided by this study.

Keywords

Lean, Chemical Management, Mcdm, BWM, Tannery

1. Introduction:

A wide range of chemicals, around 250, are used in different stages of leather production in tanning industry such as Sodium Chloride (NaCl), Soda Ash (Na_2CO_3), Lime (Calcium Hydroxide), Sodium Sulphide (Na_2S), Sodium Hydroxide (NaOH), Formic Acid (HCOOH), Sulfuric Acid (H_2SO_4), Basic Chromium Sulfate (BCS), Sodium Formate (HCOONa), Soda ($NaHCO_3$), and Amino Resins. The wide range of chemicals, machinery, equipment and processes used in the tanning industry can pose many occupational hazards and high risks to workers, especially in countries with weak law Enforcement. Many tanneries fail to adopt preventive and protective measures to improve Occupational Safety and Health (OHS) procedures, consequently putting their employees at risk (Buljan et al. 1999). The current state of chemical handling and management in Bangladesh's tanning industry shows that the condition for harmful health effects on workers is steadily getting worse. Many adverse health conditions, including as severe respiratory problems, skin-related diseases, and complex cardiovascular problems, affect a large number of workers (Naher et al. 2020). With regard to LWG certification, the state of the Bangladeshi tanning sector is getting worse every day due to a lack of compliance with chemical management, one of the most important prerequisites for certification. As a result, the company experiences a loss of clients, work orders, and reputation in the global leather market due to not having access to the leather market of Europe, the US and some developed Asian countries (Necessity of Leather Working Group Certificate)

Lean manufacturing is based on the Toyota Production System developed by Toyota which focuses on eliminating waste, reducing inventory, improving throughput, and encouraging employees to bring attention to problems and suggest improvements to fix them as it improves the work culture and management's sense of responsibility regarding waste and quality management (Mia et al. 2017, Gaikwad et al. 2020). Recently, lean manufacturing has been widely applied in the manufacturing industry around the world and is considered as one of the most effective methods in improving operational efficiency (Susilawati et al. 2015). The benefits of Lean are renowned and proven; however, several factors can lead Lean implementation to fail in different sectors, including Small and Medium-sized Enterprises (SMEs). A common observation is that the Lean Six Sigma business methodology is only implemented by organizations with large turnover numbers and a large number of people. However, it is a misconception among industrialists that Lean is only for large firms and not for SMEs. With appropriate strategies and managerial support, Lean can be adopted irrelevant of the size of the organization (Gaikwad et al. 2020). At present, Bangladesh has achieved a tremendous growth rate in its industrial production and small industry played a major rule in becoming its economy. But using green manufacturing to ensure lean production is a big challenge for those small industries (Sushil et al. 2020). Though the Bangladeshi leather industry is the oldest, it has yet to witness the impact of striking economic growth. Despite having inherent resources and positive contribution into economy, leather industry ranks fifth in export with only 3% of national exports compared to 85% by the garment sector. There are some drawbacks in the sector, such as lack of investment, lack of support of local government and modern technology, waste management procedure, R&D systems and excessive dependable characteristic over human capital, which make the industry vulnerable and unattractive both in the domestic and foreign market (Rahman 2019).

So far, the implementation of Lean on chemical management does not get much attention from the researchers. Moreover, there are some research work conducted by many researchers finding barriers or challenges in different sectors such as leather manufacturing industry (Rahman 2019), leather footwear industry (Moktadir et al. 2019), small sized industries (Sushil et al. 2020, Kathiresan and Ragunathan 2016), apparel and fashion luxury industry (Bhandari et al. 2022), and so on. Md. Abdul Moktadir et al. assessed challenges for implementing Industry 4.0 in the leather manufacturing industry (Moktadir et al. 2018) and other researchers focused on finding or examining lean activity (Susilawati et al. 2015), reverse logistics practices (Moktadir et al. 2019), etc. However, no studies have been conducted to analyze and rank barriers of lean activity on chemical handling in the leather tanning industry. So,

considering the above-mentioned issues, the necessity of a safe chemical management in tannery sector and finding the barriers for implementing lean on chemical management is very crucial. But the tanning industry of Bangladesh is still far behind to build up a safe chemical management due to some dormant and obvious reasons in chemical unloading, storing, transferring, dosing and disposing of tannery internal wastage that are accelerating the deviations in chemical management (Hossain and Hossain 2023).

Therefore, in this work, a procedure for analyzing and ranking of barriers to implement lean practices in chemical of leather manufacturing industries is proposed. After reviewing many literature, 8 barriers have been identified for testing and used MCDM tool to analyze the rank among the selected barriers.

1.1 Objectives:

The objectives of the research are:

1. To investigate the current situation and lean manufacturing practices that are being followed in the Bangladeshi Leather industry.
2. To identify the barriers and rank them using MCDM tool to implement Lean practices in chemical management in the tannery.
3. To recommend some interventions to guide the implementation of Lean in chemical handling based on findings.

2. Literature Review

It is worth saying lean can provide an organization a competitive edge by reducing cost, improving quality and productivity as well as promoting self-discipline into the organization to continuously create value for the customers (Rahman 2019). Lean practices in chemical management and handling of tanning industry become an increasingly challenging issue in Bangladesh as tannery sector is still far behind to meet the requirements of international buyers due to unsafe chemical management. On top of that, for Bangladesh tanning industry, to attain reputation, grabbing notable work order, to protect workers from adverse health effect of chemicals and to achieve a sustainable position in the international leather market, a third-party audit certification for instance, LWG certification is a vital requirement (Hossain and Hossain 2023). So the main basis of this literature review is finding barriers of implementing lean in chemical management of leather tanning industry as most researchers experimented based on different criteria such as measure degree of lean activity (Susilawati et al. 2015), study of lean manufacturing in small sized industries (Sushil et al. 2020), reverse logistics practices in the leather footwear (Moktadir et al. 2019), modeling of supply chain risk in the leather industry (Raihan et al. 2019), etc.

To identify the barriers, the keywords "Lean", "Barriers", "Obstacles", "Leather Industry", "Chemical Management" and "Bangladesh" were used in combination. While identifying and reviewing the literature, it appears that most of the previous studies have separately explored lean and six sigma methods in SMEs (Sushil 2020, Achanga et al. 2005, Belhadi et al. 2018, Belhadi et al. 2017), public healthcare (Henrique and Filho 2018), construction industry (Demirkesen and Bayhan 2022) highway engineering industry (Burawat 2019), leather manufacturing industry (Rahman 2019, Sushil et al. 2020), leather footwear industry (Moktadir et al. 2019), garment industry (Hasan 2022), and etc. However, although it is widely embedded in companies and in many different sectors of the economy, there are few studies that seek to lean practices in leather processing, especially in chemical management.

On top of that identifying barriers is an excellent way to develop strategies to overcome them during the initial stage, as costs increase with each phase and most researchers dug down to find out the effective barriers for implementing

lean in different industries (Gaikwad et al. 2020). 'Management active involvement', 'Clear communication of their vision, training and education' and 'Knowledge about process and supply chain' are the most common barriers for successfully implementing lean, green and six sigma in SMEs in the leather manufacturing industry. The literature has shown to acknowledge these factors as primary barriers which need to be addressed while implementing any quality improvement tools (Rahman 2019). On the other hand, G. Kathiresan and Dr. S. Ragunathan conducted a research for the adoption of green supply chain in the small and medium sized tanneries and found out 'Stakeholder's cooperation' and 'Environmental performance' have the most authoritative potential for consummating the green supply chain in a lucrative manner (Kathiresan and Ragunathan 2016)

Furthermore, there are more common barriers such as 'Financial status', 'Absence of integrated policy', 'Technology and Infrastructure', 'Successful Communication', 'Management and Government support', 'Lack of human resource' etc. which have been highlighted in many articles (Sushil et al. 2020, Moktadir et al. 2019, Bhandari et al. 2022). In this sense, these barriers can be taken into account while adopting new improvement tools like Lean, Total Quality Management, Six sigma etc.

Hence, from the literature available so far, it is observed that many researchers tried to find out the main barriers or obstacles to the implementation of Lean, Six Sigma, reverse logistics, green manufacturing etc. However, there are less studies found on implementing lean in the leather tanning process and no studies have been conducted to implement lean practices in chemical management which motivates us to work on this issue.

3. Methodology

The Best-Worst Method simplifies multi-criteria decision-making by asking you to pick the best and worst factors, then rate the others against them on a 1-to-9 scale. This easy comparison process generates weights for each factor, helping you prioritize choices and make confident decisions, even with complex situations. The step by step procedure is mentioned below.

Step 1: Identify Criteria

Define the decision problem clearly and then determine the relevant criteria (factors) that influence the decision.

Step 2: Determine the Best and Worst Criteria:

The most important criteria (B) is selected and them the least important criteria (W) is selected. These will be used for the pairwise comparison.

Step 3: Perform Pairwise Comparisons:

Using a pairwise comparison method, the decision-maker/expert uses the numbers 1 to 9, where 1 means equally important and 9 means significantly more important, to determine a preference for B over the other criteria. These other figures represent the intermediate assessments. The vector $A_B = (a_{B1}, a_{B2}, \cdots, a_{Bj}, \cdots, a_{Bn})$ is the outcome of this phase, where a_{Bj} represents the preference of criterion B over criterion j.

Step 4: Compare Others to the Worst Criterion:

The 1 to 9 scale is used to assess the preferences for the other criteria over the worst criterion. The outcome of Step 4 is represented by the vector $A_w = (a_{1W}, a_{2W}, \cdots, a_{jW}, \cdots, a_{nW})$, where a_{jW} represents the preference for criterion j over criterion W.
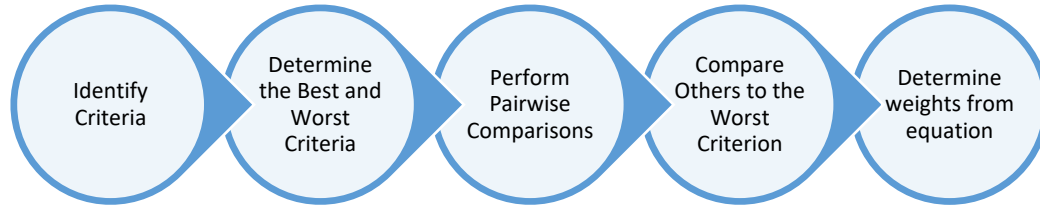
Figure 1: Methodology of BWM

Step 5: Liner programming model used to determine the weights $W_1, W_2, W_3 \ldots \ldots W_N$

$$\min \max_j \{ \left| \left| w_B - a_{Bj} w_j \right| \right|, \left| \left| w_j - a_{jW} w_W \right| \right| \} \text{---------------------------------}(1)$$

such that $\sum n \, j{=}1$

$wj = 1 \; wj \geq 0$, for all j

To determine the weights of the criteria ($w_1, w_2, \cdots, w_n$)

Consistency ratio = ξ^* /Consistency

where ξ^* is the result of the objective function 1.

The inventor if the Best worst method Dr. Jafar Rezaei has published a solver where the liner programming is done via excel and gives the final output result. In this research the solver excel has been used.

4. Calculation:

Step 1: Identify Criteria

The criterions are identified from the previous literatures and the list of the critron are given in the table below.   Table 1: Identified Critrions

Main barriers/drivers/enablers
• Successful communication
• Stake Holders Cooperation
• Environmental Performance
• Technical Capabilities
• Lack of management commitment
• Organizational Policy
• Operational issue
• finance barriers

Step 2: Determine the Best and Worst Criteria

From the different tannery associates and the industry experts the best criterion chosen was Operational issue. When implementing the lean manufacturing or any other new method the worker operational issues become the most vital point to be resolved. The least important one was Organizational Policy.

Step 3: Perform Pairwise Comparisons

Table 2: Pair-wise comparison

Best to Others	Successful communication	Stakeholders Cooperation	Environmental Performance	Technical Capabilities	Lack of management commitment	Organizational Policy	Operational issue	Finance barriers
Operational issue	4	3	2	6	7	9	1	2

The scores are assigned by the Manager 1.

Step 4: Compare Others to the Worst Criterion

Table 3: Worst to other factor comparison

Others to the Worst	Organizational Policy
Successful communication	3
Stakeholders Cooperation	2
Environmental Performance	9
Technical Capabilities	2
Lack of management commitment	2
Organizational Policy	1
Operational issue	5
Finance barriers	7

The scores are assigned by the Manager 1.

Step 5: Liner programming model used to determine the weights W_1, W_2, W_3...... W_N

The inventor if the Best worst method Dr. Jafar Rezaei has published a solver where the liner programming is done via excel and gives the final output result. In this research the solver excel has been used.

The Weights found are

Table 4: Final Weight Table

Weights	Successful communication	Stakeholders Cooperation	Environmental Performance	Technical Capabilities	Lack of management commitment	Organizational Policy	Operational issue	Finance barriers
	0.1112	0.1112	0.2225	0.0556	0.0494	0.0468	0.3396	0.0636

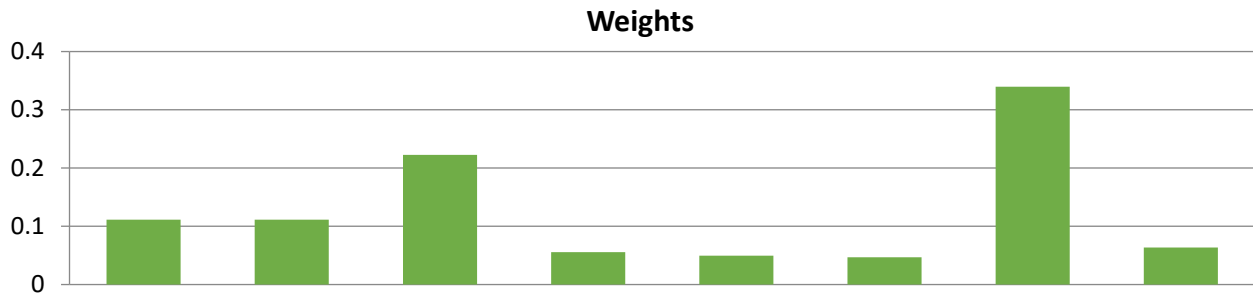*Figure 2: Weights of the Criterions*

Consistency ratio = ξ* /Consistency, where the ratio CR<=.10 is acceptable and the maximum threshold is 0.4543 which is also acceptable.

Input-Based CR	0.098
Associated Threshold	0.362

5. Conclusion

Safe chemical management has become a clearly demanding topic for Bangladesh's tannery sector as a result of the industry's struggles to meet the demands of international brands and buyers due to its non-compliance with regulations regarding unsafe chemical handling, which results in the loss of customers, reputation, work orders, and negatively impacts the health of workers (Hossain and Hossain 2023). After reviewing many articles, the authors found that no specific studies have been done for lean implementation in chemical section as Lean production is one of the powerful transformations that has been widely explored and practiced by a meaningful number of organizations worldwide (Belhadi et al. 2018). Moreover, Lean offers various benefits for industry practitioners, such as preventing rework and addressing safety concerns in addition to enhancing customer satisfaction and meeting quality standards. Nevertheless, the benefits of Lean have not yet been well understood by industry practitioners for several reasons, such as the cost of using Lean tools or the lack of experience in Lean implementation (Demirkesen and Bayhan 2022).

Thus this study focuses on identifying the major barriers for implementing successful lean practices in the chemical management, weighing and ranking them using MCDM's Best-Worst method tool. Within this context, 8 main factors were identified such as successful communication, Stakeholders Cooperation, Environmental Performance, Technical Capabilities, Lack of management commitment, Organizational Policy, Operational issue, and Finance barriers that are liable for chemical management deviation in Bangladesh tanning industry. After finalizing the factors or barriers from literature review, few tannery industry experts were selected for their feedback about the selected barriers. In the context of Bangladesh, 'Operational Issue' was found to be the foremost barrier and 'Organizational Policy' was found to be the worst or least barrier to implementing Lean activity in the chemical section. The factor 'Operational Issue' means that the majority of the workers have inadequate knowledge in chemical storage and unloading due to the lack of training. Also, they have inadequate knowledge about every chemical operation and the consequences of poor chemical handling in the tanning industry. Moreover, solutions like development of organizational learning culture, early deployment of lean culture through training and allocation of sufficient time and resources for change are also important.

The study consists of some limitations, the aforementioned claim can only be justified within the resources and time constraints in which this study was conducted. Firstly, feedback taken from the participants or industry experts to analyze were limited. Secondly, the research for leather industry is limited and that is why less research paper for lean implementation was found on different databases such as scopus, google scholar etc. This research can help other Bangladesh industries, such as textile, food processing, polymer, pharmaceuticals, and etc. adopt Lean practices in their manufacturing. All of these industries have substantial impacts on the environment and society. This research can help industrial managers and planners develop strategies to overcome these barriers.

References

Achanga, P., Shehab, E., Roy, R., and Nelder, G., Critical success factors for lean implementation within SMEs, *Journal of manufacturing technology management*, vol. 17, no. 4, pp. 460-471, 2006.

Belhadi, A., Touriki, F. E., and El Fezazi, S., Lean implementation in small and medium-sized enterprises in less developed countries: Some empirical evidences from North Africa, *Journal of Small Business Management*, vol. 56, pp. 132-153, 2018.

Belhadi, A., Touriki, F. E., and El Fezazi, S., Prioritizing the solutions of lean implementation in SMEs to overcome its barriers: An integrated fuzzy AHP-TOPSIS approach, *Journal of Manufacturing Technology Management*, vol. 28, no. 8, pp. 1115-1139, 2017.

Bhandari, N., Garza-Reyes, J. A., Rocha-Lona, L., Kumar, A., Naz, F., and Joshi, R., Barriers to sustainable sourcing in the apparel and fashion luxury industry, *Sustainable Production and Consumption*, vol. 31, pp. 220-235, 2022.

Buljan, J., Sahasranaman, A., and Hannak, J., Occupational safety and health aspects of leather manufacture: guidelines and recommendations for managers and supervisors of tanneries and effluent treatment plants, 1999.

Burawat, P., PRODUCTIVITY IMPROVEMENT OF HIGHWAY ENGINEERING INDUSTRY BY IMPLEMENTATION OF LEAN SIX SIGMA, TPM, ECRS, AND 5S: A CASE STUDY OF AAA CO., LTD., *Humanities & Social Sciences Reviews*, vol. 7, no. 5, pp. 83-92, 2019.

Demirkesen, S., and Bayhan, H. G., Critical success factors of lean implementation in the construction industry, *IEEE Transactions on Engineering Management*, vol. 69, no. 6, pp. 2555-2571, 2019.

Gaikwad, S. K., Paul, A., Moktadir, M. A., Paul, S. K., and Chowdhury, P., Analyzing barriers and strategies for implementing Lean Six Sigma in the context of Indian SMEs, *Benchmarking: An International Journal*, vol. 27, no. 8, pp. 2365-2399, 2020.

Hasan, M. M., Implementation of Lean Tools in the Garments Industry to Improve Productivity, 2021.

Henrique, D. B., and Godinho Filho, M., A systematic literature review of empirical research in Lean and Six Sigma in healthcare, *Total Quality Management & Business Excellence*, vol. 31, no. 3-4, pp. 429-449, 2020.

Hossain, M. A., Chemical Handling in Tannery: An Empirical Analysis of Chemical Management in Tanning Industry, Savar, Bangladesh, 2023.

Kathiresan, G., and Ragunathan, S., An exploratory study of drivers for the adoption of green supply chain management in small and medium sized tanneries of northern Tamilnadu using ISM, ANP and Fuzzy ANP, *Advances in Natural and Applied Sciences*, vol. 10, no. 16, pp. 103-115, 2016.

Mia, M. A. S., Application of Lean Tools for the Improvement of Process Cycle Efficiency of Moccasin Shoe Production Line, *International Journal of Engineering and Management Research (IJEMR)*, vol. 7, no. 6, pp. 124-133, 2017.

Moktadir, M. A., Ali, S. M., Kusi-Sarpong, S., and Shaikh, M. A. A., Assessing challenges for implementing Industry 4.0: Implications for process safety and environmental protection, *Process safety and environmental protection*, vol. 117, pp. 730-741, 2018.

Moktadir, M. A., Rahman, T., Ali, S. M., Nahar, N., and Paul, S. K., Examining barriers to reverse logistics practices in the leather footwear industry, *Annals of Operations Research*, vol. 293, pp. 715-746, 2020.

Naher, U. H. B., Kabir, M. H., Begum, M. L., and Sarker, M. R., Health Issues of Tannery Workers at Savar, Dhaka, Bangladesh, vol. 7, no. 12, 2020.

Necessity of Leather Working Group Certificate, available: https://www.dailytribunal24.com/sub-editorial/33119

Rahman, M. M., Lean, Green and Six Sigma in SMEs: A Case Study of SMEs in Leather Manufacturing (Doctoral dissertation, University of the West of Scotland), 2019.

Raihan, A., Islam, F., and Ali, S. M., Modelling of Supply Chain Risks in the Leather Industry, *In Proceedings of the 2019 IEOM International Conference, Toronto, Canada*, pp. 23-25, 2019.

Sushil, S., Islam, M. S., Islam, T., and Khan, M. S. I., Approach of green and lean manufacturing study of the small industries in Bangladesh, *Research Journal of Engineering Sciences*, pp. 9472

Susilawati, A., Tan, J., Bell, D., and Sarwar, M., Fuzzy logic based method to measure degree of lean activity in manufacturing industry, *Journal of Manufacturing Systems*, vol. 34, pp. 1-11, 2015.

Biographies

Md. Mahfujul Haq, an experienced Industrial and Production Engineer, currently working as a Research Assistant at in Susleather project co-hosted by Ahsanullah University of Science and Technology and University of Southern Denmark. He as completed Master of Engineering in Advanced Engineering Management from Bangladesh University of Engineering and Technology (BUET). Previously he has completed Bachelor of Science in Industrial and Production Engineering. Basic area of expertise is data monitoring, data analysis, project evaluation, and Baseline-endline studies.

Prof. Dr. Mohammad Sarwar Morshed is a Professor of Industrial & Production Engineering in the Department of Mechanical & Production Engineering, Ahsanullah University of Science and Technology (AUST), Dhaka, Bangladesh. He is also the Leader of the SusLeather Project- Bangladesh part. His area of expertise is Heuristic and Intelligent Tools, Genetic Algorithms and Machine Learning, Lean, OHS, and Life Cycle Assessment, Combinatorial Optimization in Applied Engineering, Supply Chain Management, Public Health, Computer Integrated Manufacturing.

Mongsathowai Marma is a currently working as a Research Assistant at in Susleather project co-hosted by Ahsanullah University of Science and Technology and University of Southern Denmark. He has completed both of his Bechalor and Masters Education from Institute of Leather Engineering, University of Dhaka. His area of interest is Lean manufacting, Chemical Safety, Leather Production Operations and Quantative Analysis.

Dr. Abu Hamja, is working as an Assistant Professor of Mechanical Engineering Engineering in the Department of Mechanical & Production Engineering, Ahsanullah University of Science and Technology (AUST), Dhaka, Bangladesh. He is also the Deputy Leader of the SusLeather Project.His are of expertise includes the multidisciplinary strategies for preventing Musculoskeletal Disorders and Work Disability, Lean-Agile methodologies, OHS, and organizational transformation.