Developing a Sustainable Environmental Management Plan: A Case Study of a Readymade Garment Factory

Md. Kamrul Hasan Chowdhury, Md. Tanvir Siraj
Boiler Safety Engineer, RMG Sustainability Council, Dhaka-1212, Bangladesh
kamrul.chowdhury@rsc-bd.org, tanvir25392@gmail.com

Nazrul Islam
Department of Mechanical Engineering,
Rajshahi University of Engineering and Technology, Rajshahi 6204, Bangladesh
shakilnazrul67@gmail.com

Spandan Basak Payel
Department of Mechanical Engineering
Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh
spandanbasak@gmail.com

Debashis Biswas
Department of Electrical Engineering, National Institute of Technology, Silchar, India
debashis.bs@hotmail.com

Abstract

Environmental management is a critical issue for the readymade garment (RMG) industry, as it is a significant contributor to environmental degradation and pollution. Effective environmental management planning (EMP) is crucial for RMG factories to reduce their environmental impact and promote sustainability. This research focuses on the development of a sustainable EMP as a case study for an RMG factory, intending to address the environmental challenges facing the industry. The factory was segmented into 24 different sections, and activities for each section were enlisted to determine their environmental impact. Using a risk matrix analysis, the study identified noise pollution from various sources, such as from winding, auto placket, back winding, electricity generator, and compressor section, as well as water pollution from the washing section and stack air emission from the generator and boiler section, as the biggest environmental risks. The findings of this study provide valuable insights into the environmental impact of the RMG industry, highlighting the challenges it faces in terms of sustainability. The study underscores the need for effective management strategies to address these challenges and promote sustainability.

Keywords
Environmental management plan, Readymade garment factory, Risk management, Risk matrix, Sustainability

1. Introduction
The readymade garment (RMG) industry plays a significant role in many countries' economies and employs millions of people worldwide (Zor 2023). However, the industry has faced criticism for its negative impact on the environment and its labor practices (Saha et al. 2023). To address these challenges, many companies in the industry are looking to adopt sustainable and environmentally responsible business practices (Yang et al. 2023). This case study focuses on the development of a comprehensive environmental management plan (EMP) for an RMG factory, intending to reduce its negative impact on the environment while ensuring its long-term viability. The purpose of this study is to explore the design and implementation of such a plan and to evaluate its effectiveness in achieving its goals.

The RMG industry is vital for Bangladesh for several reasons. Firstly, it is the largest contributor to the country's economy, accounting for more than 80% of the total exports and providing employment to millions of workers (Siraj et al. 2022a). Secondly, the industry has played a key role in the development of Bangladesh's economy, helping to improve the standard of living for many families and reducing poverty (Chowdhury et al. 2022). Additionally, the industry has attracted significant investment, both domestically and internationally, boosting the country's overall economic growth (Siraj et al. 2022b). Finally, the RMG industry has helped to position Bangladesh as a major player in the global apparel market and has established the country as a hub for low-cost, high-volume clothing production (Islam and Halim 2022). All of these factors combined make the RMG industry a crucial component of Bangladesh's overall economic development.

However, despite the importance of the RMG industry, there has been a lack of research and focus on developing comprehensive EMP for these factories. This is likely due to a combination of factors, including a lack of awareness about the importance of environmental management, limited resources and funding for such initiatives, and a lack of understanding about the most effective methods for reducing the industry's impact on the environment (Rahman 2021). As a result, many RMG factories in Bangladesh continue to operate without adequate EMP, leading to negative consequences for both the environment and the workers who depend on the industry for their livelihoods (Aktar and Islam 2019). To address this issue, researchers, policymakers, and industry leaders need to prioritize the development of EMP for the RMG industry in Bangladesh.

Several recent studies in the existing literature have addressed different aspects of environmental impact and environmental management in the RMG sector (Abdin 2017; Ahmed et al. 2018; Aktar and Islam 2019; Ahmed et al. 2019; Bristi et al. 2020; Rahman 2021; Rahman and Dey 2021; Hossen et al. 2021; Shumon and Rahman 2022; Saha et al. 2023). However, none of these studies have been conducted to develop a sustainable EMP for the RMG industry, thus contributing to achieving sustainable development goals (SDGs). Therefore this study has performed a risk matrix-based environmental risk analysis of an RMG factory as a case study to develop a comprehensive framework to assist industrial managers and policymakers.

The risk matrix approach is a well-known method to identify the risk factors and their severity by determining the risk scores of each of the risk factors from their aspect and impact (Ni et al. 2010; Bari et al. 2022). This method has been previously applied for analyzing risk factors of different industrial areas such as wastewater treatment plants (Kosma et al. 2014), the heavy metal industry (Maanan et al. 2015), the civil construction sector (Youli et al. 2018), risk assessment for fuel storage tank (Ikwan et al. 2021), risk assessment for an energy sector (Ibrahim et al. 2022), and so on. However, no study has been observed with the utilization of the risk matrix approach to developing EMP in the RMG industry. Hence, this study is a novel approach to contribute to the existing literature.

This study is addressing gaps in the existing literature by focusing specifically on developing a comprehensive EMP for an RMG factory. By doing so, this study is filling a crucial gap in the existing knowledge and providing important insights and recommendations that can help the industry to operate in a more sustainable and environmentally responsible manner. The fact that this study is novel and addresses a specific problem makes it an important contribution to the field of environmental management in the RMG industry and highlights the need for further research in this area.

1.1 Objectives

This study is going to contribute to the literature by fulfilling the following objectives:

a) To analyze the current environmental practices of an RMG factory in Bangladesh.
b) To design and access a sustainable EMP with a case study from an RMG factory.

The rest of the paper is constructed as, Section 2 will review the closely related literature on this field of study, Section 3 will describe the methodology for developing the case study, Section 4 will discuss the study results, Section 5 will present the managerial implications of this study in achieving SDGs, finally, Section 6 will conclude the study by summarizing the findings and limitations of the study as well as proposing some future study scope.

2. Literature Review

An environmental management plan (EMP) is a comprehensive document that outlines an organization's strategies, policies, and procedures for managing its environmental impacts (Alexis 2021). The main purpose of an EMP is to minimize the negative environmental impacts of an organization's activities and to promote sustainable practices (PART and Waters 2021). An EMP typically covers various aspects of environmental management, including waste management, energy and resource efficiency, air and water quality management, and greenhouse gas emissions reduction (Baby 2011). The EMP is based on a thorough analysis of the organization's environmental impact and risks, and it outlines specific actions and targets to address these impacts and risks. The EMP is regularly reviewed and updated to ensure that it remains relevant and effective in promoting sustainable practices (Khan 2017).

The significance of environmental management has been analyzed in several previous studies. For instance, Muhib et al. (2021) found a moderate risk of water pollution and low risks in air quality, soil quality, noise, waste generation, hazardous material handling, and miscellaneous use in environmental aspects of the textile industry. Alexis (2021) described environmental management has gained significant momentum in Latin America and the Caribbean, particularly after the Rio de Janeiro Summit on Environment and Development. Most countries have established extensive environmental legislation. Gunasekara (2020) explored the voluntary use of environmental management practices in green apparel manufacturing enterprises in Sri Lanka through a qualitative multiple-case study. The findings provide insights into how environmental management can improve brand image, enhance productivity, and accurately account for environmental costs in organizations. Zor (2023) depicted environmental regulations have a positive impact on promoting sustainable transition in the textile and apparel industry in China, as shown by a study based on public data of 24 companies for 15 years. However, this promotion effect can be negatively influenced by deviant strategy.

Yang et al. (2023) conducted a study based on 553 firm-year observations of 74 Chinese textile and apparel firms and found a U-shaped relationship between firm digitalization and environmental performance, with positive moderation from strong technical and financial backgrounds, and high education levels of top management. This research provides insights for companies to optimize their top management structure to increase the benefits of digitalization for environmental performance. Rahman (2021) aimed to examine the implications of green management practices in the readymade garment industries of Bangladesh, surveying 100 employees to assess their perceptions of environmental sustainability. The study found that investment in green management systems, recording and disclosure of performance, employee participation in green discussions, and a specific code of conduct for green management are the most important factors in promoting environmental sustainability. Hossen et al. (2021) also showed a positive impact of environmental management practices on the performance of apparel manufacturing industries.

Ahmed et al. (2019) propose a structured framework for occupational risk assessment in the ready-made garment (RMG) sector in Bangladesh, using the Analytic Hierarchy Process (AHP) and Quality Function Deployment (QFD) methods. The study found that fire, contagious diseases, and noise are the top priority safety, health, and environmental risk factors in the industry, and the results of the assessment may help the garment industry effectively address these issues through proper identification and mitigation of the most influential risk factors. Patnaik and Tshifularo (2021) claimed that the apparel industry contributes to climate change due to waste produced during garment manufacturing and end-of-life clothing. Pollution from clothing can be reduced through recycling and reusing methods to create new materials. Vishwakarma et al. (2022) identify challenges in the Indian apparel industry, including environmental, social, and economic sustainability issues. The study suggests sustainability practices to address these challenges, with a focus on environmental protection. However, it concludes that more significant initiatives will be needed in the future for a better environment and sustainability.

de Z Gunathilaka and Gunewardena (2014) examined the Sri Lankan apparel manufacturing industry's impact on global warming through their contribution to CO_2 emissions. Results highlighted the relationship between carbon emission and the burning of fossil fuels, but low awareness at the corporate level. The paper developed a model for the effect of greenhouse gases on carbon offsetting and neutrality, and emphasise environmental management. Zhang and Dong (2023) explored the impact of environmental and psychological factors on second-hand apparel recycling intention (SARI) in China. Results aimed to provide insight into how to improve SARI in emerging economies from an environmentally psychological perspective.

The above discussion highlights, previous studies have emphasized the fact that environmental performance can enhance sustainability in business models, and at the same time, it can demonstrate social responsibility by improving environmental quality. Despite the importance of environmental management, the implementation of EMP is not a widely accepted practice in the factories of Bangladesh. Therefore, a case study to develop an EMP can be of practical significance for the factories in Bangladesh. The case study can provide a deeper understanding of how EMP can be implemented and help factories in Bangladesh adopt environmentally responsible practices. This can lead to better environmental performance and sustainable development for the industry.

3. Methods of developing EMP

For generating a framework for EMP, this study has applied a structured approach as shown in Figure 1. An RMG factory situated in the Gazipur district (the name of the factory is kept confidential) of Bangladesh has been taken as a case study to conduct this study. Details methodology for this study is as follows:

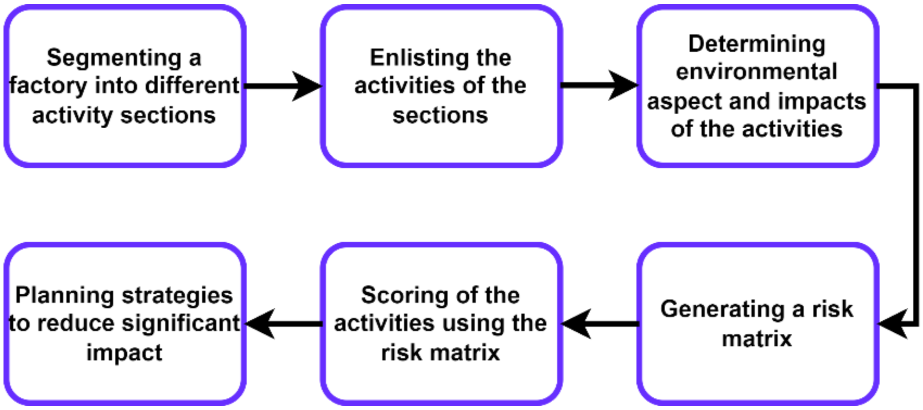

Figure 1. EMP methodology for this study

3.1 Segmenting an RMG factory into different activity sections:

The factory which has been selected for this study was segmented into the below sections shown in Table 1. Activities of the sections are also mentioned in brief in Table 1.

Table 1. Segmenting an RMG factory into different activity sections

Denotation	Section	Activity
S1	Yarn Store	Storage and unloading of yarn for distribution
S2	Winding	Soften the yarn with the application of wax
S3	Knitting	Fabric knitting with an auto-knitting machine
S4	Linking	Linking separate joints of garments
S5	Trimming	Trimming of excess thread/excess portion from the garments
S6	Mending	Identification and rectification of linked garments
S7	Washing	Fabric washing with softener, detergent, and silicon, and drying the wet-washed fabric at a dryer
S8	Sewing and additional attachment	Label, button, and lace attachment
S9	Spot removing	Removing spots from the finished product
S10	Iron	Ironing the garments
S11	Quality control	Quality check for the finished product for any fault or measurement shrinkage
S12	CAD Section	Printing of marker
S13	Packing	Checking for metal fragments and packing of finished garments
S14	Auto Placket Section	Making of placket
S15	Back winding section	Dismantle the rejected fabric to reclaim the yarn; rewind and submit to the distribution section
S16	Sample Section	Trial production activity
S17	Effluent treatment Plant (ETP)	Treatment of wastewater coming from the washing process
S18	Generator	Generation of electricity
S19	Boiler	Groundwater withdrawal, Use of natural gas to operate the boiler, and generation of Steam
S20	Compressor	Generation of compressed air

S21	Cooling Tower	Reject waste heat to the atmosphere
S22	Chemical store	Storage of chemicals
S23	Oil Store	Storage of machine oil, lube oil, diesel, mobile, compressor oil, etc.
S24	Wastage Store	Storage of garments waste fabrics

3.2 Determining aspects and impacts of different activities and their risk scores:

The risks were evaluated and prioritized using a Risk Ranking Tool and a Risk Matrix, taking into account the severity of the potential consequences and the likelihood of their occurrence. The consequence severity on which the risk matrix was established can be found in Table 2.

Table 2. Consequence severity table

	Health and Safety	**Environment and Community**
Major	Severe impact on human health (e.g.Poisoning) Prolong exposure may cause epidemic/death	Destruction of wildlife or plants or their habitat Long-term environmental damage The devastation to a large area of land/water body Severely affecting the health of a localcommunity Community complaints received with impact at the national level
Significant	Prolong exposure cause mental/physicalinstability or disease Long-term healthdamage	Severely affect wildlife or plants Emission/discharge exceeding legal standardand is reportable to a government authority Legally actionable activity Community complaints received with impact at the local level
Moderate	Damage workenvironment Prolong exposure cause nuisance/minorillness	Minor level pollution can be alleviatedby simple mitigation measures Non-compliance with internal environmental target Concern by the local community, environmental matter
Minor	No impact on human health and safety	No direct pollution to any environmentalcomponent No community complaints No breach of regulation or consent

Classification of the likelihood to prepare the risk matrix can be found in Table 3.

Table 3. Likelihood classifications

Certain	**Likely**	**Moderate**	**Unlikely**	**Rare**
The event is expected to occur on most occasions.	The event is expected to occur on many occasions.	The event is expected to occur on some occasions.	The event isexpected to occur infrequently.	The event mayoccur in exceptional circumstances.
Frequency: Atleast once per week	Frequency: Atleast once per month	Frequency: Atleast once in 6months	Frequency: At least once a year	Frequency: Lessthan once a year

The designed risk matrix for this study is shown in Table 4.

Table 4. Risk matrix

Consequences		**Likelihood**				
		Rare	Unlikely	Moderate	Likely	Certain
		U	**V**	**X**	**Y**	**Z**
Minor	**A**	**AU**	**AV**	**AX**	**AY**	**AZ**
Moderate	**B**	**BU**	**BV**	**BX**	**BY**	**BZ**
Significant	**C**	**CU**	**CV**	**CX**	**CY**	**CZ**
Major	**D**	**DU**	**DV**	**DX**	**DY**	**CZ**
Low Risk			**Moderate Risk**		**High Risk**	

In risk analysis, aspect refers to the specific element or feature of a system or process that could give rise to a risk. Impact refers to the consequences or effects that would result from the realization of a risk. In risk analysis, both aspects and impacts are analyzed to determine the level of risk and guide risk management strategies. The focus of environmental management during the operational phase should be on managing the risks associated with air quality, noise generation, and waste generation at the factory. Responsible persons for the EMP should be top management, the manager (human resource and compliance), the manager (production and maintenance), and the manager (health and safety). The aspect and impact of the activities were designed with a brainstorming session with the managerial bodies of the factory. Finally, a risk scoring was generated which can be found in Table 5.

Table 5. Aspects, impacts, and risk scoring of risk factors

Section	Aspect	Impact	Risk Score	Risk Status
S1	Generation of solid waste(waste poly, sack, waste thread cone, carton)	Degradation of land and water body	**BX**	**Low**
S2	Use of electricity	Resource depletion	**AZ**	**Moderate**
	Dust and particulate matter generation	Air pollution	**BX**	**Low**
	Generation of noise	Noise pollution	**CZ**	**High**
S3	Generation of solid waste (waste fabric, thread, wastepoly, waste thread cone)	Degradation of land and waterbody	**BX**	**Low**
S4	Generation of solid waste(waste thread, thread cone,waste poly, waste fabric, broken needle)	Degradation of land and water body	**BX**	**Low**
S5	Solid waste generation (waste thread, fabric, poly)	Degradation of land and water body	**BX**	**Low**
S6	Solid waste generation	Degradation of Land and waterbody	**BX**	**Low**
S7	Use of water	Depletion ofnatural Resources	**AZ**	**Moderate**
	Wastewater generation	Water pollution	**CZ**	**High**
	Heat and humidity generation	Air pollution	**BZ**	**Moderate**
S8	Generation of solid waste(waste thread, label, waste poly, empty thread cone, broken needle, etc)	Degradation of land and waterbody	**BX**	**Low**
S9	Volatile organic compounds generation	Air pollution	**BZ**	**Moderate**
S10	Use of steam	Resource depletion	**AZ**	**Moderate**
S11	Generation of solid waste (thread fragment)	Degradation of Land and waterbody	**BX**	**Low**
S12	Generation of solid waste (waste marker paper)	Degradation of Land and waterbody	**BX**	**Low**
S13	Solid waste (waste sticker,waste poly, waste carton, waste plastic hanger, waste metal fragment)	Degradation of land and waterbody	**BY**	**Moderate**
S14	Generation of noise	Noise pollution	**CZ**	**High**
	Dust and particulate matter generation	Air pollution	**BX**	**Low**
S15	Solid waste generation (waste thread, fabric, emptythread cone)	Degradation of land and waterbody	**BY**	**Moderate**
	Use of electricity	Resource depletion	**AZ**	**Moderate**
	Noise generation	Noise pollution	**CZ**	**High**
	Dust and particulate matter generation	Air pollution	**BY**	**Moderate**
S16	Solid waste (waste fabric,sticker, thread)	Degradation of land and waterbody	**BX**	**Low**
	Generation of noise	Noise pollution	**BX**	**Low**
	Dust generation	Air pollution	**BX**	**Low**

Section	Aspect	Impact	Risk Score	Risk Status
S17	Use of water for chemical mixing	Depletion of natural resources	AZ	Moderate
	Wastage of chemicals from chemical use	Degradation of land and water body	CX	Moderate
	Noise generation	Noise pollution	BZ	Moderate
S18	Use of diesel to operate the generator Use of water to cool down the generator	Depletion of natural resources	AZ	Moderate
	Stack air emission	Air pollution	CZ	High
	Generation of noise	Noise pollution	CZ	High
	Generation of high temperature	Air pollution	BZ	Moderate
S19	Use of water to generate steam	Depletion of natural resources	AZ	Moderate
	Stack air emission	Air pollution	CZ	High
	Generation of high temperature	Air pollution	BZ	Moderate
	Wastage of steam from leakage	Air pollution	BY	Moderate
S20	Generation of noise	Noise pollution	CZ	High
	Dust generation	Air pollution	BX	Low
S21	Use of water	Depletion of Natural resources	AZ	Moderate
	Wastewater generation from the cooling tower blows down	Water pollution	BZ	Moderate
S22	Volatile organic compounds generation	Air pollution	BX	Low
	Potential for chemical wastegeneration	Degradation of Land and waterbody	CV	Moderate
S23	Generation of waste oil (machine oil, compressor oil)	Degradation of land and waterbody	CV	Moderate
S24	Generation of solid waste	Degradation of land and water body	BX	Low

4. Results and Discussion

The result shows that the generation of noise from sections S2, S14, S15, S18, and S20, wastewater generation from section S7, and stack air emission from sections S18 and S19 are the most prioritized environmental pollutants from an RMG factory. This result is significant to design an effective mitigation plan for environmental pollution. The top prioritized sections need to be monitored carefully by the management. This will be helpful to generate a stratified mitigation plan to reduce the adverse impacts on the environment due to regular operations of the factory. A summarized presentation of the obtained result can be found in Figure 2.

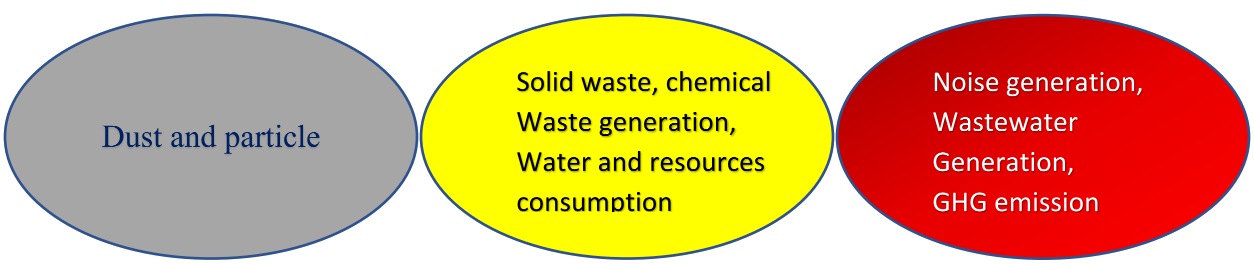

Figure 2. A summarized presentation of the obtained results

The operation of the power generator and other sections of a readymade garment (RMG) factory is responsible for the generation of noise pollution. The noise produced by these sections can have negative impacts on both the environment and human health. Prolonged exposure to excessive noise levels can lead to hearing loss, increased stress, sleep disturbance, and decreased overall well-being. Additionally, noise pollution can also disrupt the balance of ecosystems, affecting wildlife behavior and communication. To mitigate these impacts, appropriate noise control measures should be implemented to keep the neighborhood impact within the limits set by the Department of Environment (DoE) and international standards.

In an RMG factory, wastewater can be generated from various sources such as the production process, domestic requirements of the workers, and other sources. Wastewater is typically produced from the activities that occur within the factory and can contain various chemicals, pollutants, and other substances that are harmful to the environment and human health. The impact of wastewater on the environment can be significant as it can contaminate water sources, soil, and air. The presence of toxic chemicals and pollutants can harm aquatic life and wildlife, reducing biodiversity and potentially leading to ecosystem collapse. Wastewater can also impact human health by contaminating drinking water sources, which can lead to the spread of water-borne diseases and other health issues. To minimize the impact of wastewater, it is important for RMG factories to properly manage and treat their wastewater before discharging it into the environment. This may involve implementing treatment processes such as chemical oxidation, filtration, and other methods to remove harmful pollutants and ensure that the water being discharged meets environmental regulations and standards.

Stack air emission refers to the release of gases and particulates into the atmosphere through the chimneys or stacks of an RMG factory. This environmental impact can be caused by various sections of the factory, including power generators, boilers, and other industrial processes. The impact of stack air emissions on the environment and human health can be significant. Emissions of pollutants such as sulfur dioxide and particulates can contribute to air pollution, which can harm both human health and the environment. Exposure to these pollutants can cause respiratory and cardiovascular problems, as well as contribute to climate change. Additionally, stack air emissions can also contribute to soil and water pollution, and negatively impact wildlife and biodiversity. To minimize these impacts, RMG factories need to implement proper control measures, such as using cleaner technologies and following environmental regulations. The factory's operations also result in the generation of solid waste, which needs to be properly segregated and stored. The factory must sell its solid waste to third-party recyclers regularly.

In addition to any negative impacts, the factory is employing a significant number of people and has contributed to the establishment of new businesses and residential areas. The factory's production of export garments is also providing employment and generating foreign currency. If the factory operates in compliance with all environmental regulations, it is expected to have a positive impact on the community. Despite the potential for negative impacts, the factory is expected to proceed without causing unacceptable harm to the environment through the implementation of the proposed mitigation measures. However, reducing the adverse effects will require ongoing attention and funding, and the factory must consider this to ensure meaningful and sustainable development with a positive impact on the nation and its people.

Risk matrix-based studies are a useful tool for industrial managers as they provide a hierarchical solution to identify and mitigate environmental risks in a factory setting, such as those found in an RMG factory. The risk matrix helps to prioritize the risks based on their likelihood of occurring and the potential consequences of their occurrence. For example, in an RMG factory, some high-risk factors might include air pollution from stack emissions, which can harm the air quality and lead to respiratory health problems for workers and nearby residents. Another high-risk factor could be the release of hazardous chemicals into the surrounding environment, which can harm wildlife and groundwater sources.

Once these high-risk factors have been addressed and mitigated, the focus can then turn to moderate risk factors, such as the generation of noise and vibration from machinery operation. These impacts may not pose a direct risk to human health, but can still cause discomfort and annoyance to workers and residents. Finally, the focus can shift to low-risk factors, such as the proper management and disposal of solid waste generated from the factory's operations. While these impacts are relatively minor compared to the high and moderate risks, they still contribute to overall environmental impact and should not be neglected.

Overall, the risk matrix approach is an effective strategy for industrial managers to identify, prioritize, and mitigate environmental risks in a systematic and efficient manner. By addressing the high-risk factors first, the factory can ensure the protection of human health and the environment, while also contributing to sustainable development in the region.

5. Managerial Implications

The managerial implications of this study are as follows:

- Identification of Environmental Risks: The risk matrix analysis conducted in this study identified the biggest environmental risks facing the readymade garment factory. This information is crucial for management to prioritize and address these risks effectively.
- Promoting Sustainability: The findings of this study highlight the need for effective EMP to promote sustainability in the RMG industry. This information can be used to develop and implement strategies that reduce the factory's environmental impact and promote sustainability.
- Improved Environmental Performance: Effective EMP can help the RMG factory improve its environmental performance, reducing its environmental impact and meeting regulations and industry standards.
- Increased Cost Savings: Implementing effective environmental management strategies can lead to cost savings by reducing waste, improving energy efficiency, and reducing liability and regulatory risks.
- Improved Reputation: A commitment to environmental sustainability can enhance the reputation of the RMG factory, attracting customers and investors who prioritize environmental responsibility.

Effective EMP is crucial to address the environmental challenges facing the industry and promote sustainability. This study can be correlated with achieving sustainable development goals (SDGs) in the following ways:

- SDG 6: Clean Water and Sanitation - The study identifies water pollution from the washing section as one of the biggest environmental risks facing the readymade garment factory. Effective management of this risk can contribute to achieving SDG 6 by reducing water pollution and promoting clean water and sanitation.
- SDG 7: Affordable and Clean Energy - The study highlights the importance of reducing air emissions from the generator and boiler sections. Improving energy efficiency and reducing emissions can contribute to achieving SDG 7 by promoting the use of affordable and clean energy.
- SDG 8: Decent Work and Economic Growth - The RMG industry is a significant contributor to the global economy and employs millions of people. The findings of this study highlight the need for effective EMP to promote sustainability in the industry, supporting the achievement of SDG 8 by promoting decent work and economic growth.
- SDG 12: Responsible Consumption and Production - The study underscores the importance of reducing the environmental impact of the RMG industry, which is a significant contributor to environmental degradation and pollution. Effective EMP can contribute to achieving SDG 12 by promoting responsible consumption and production.

6. Conclusion

This study aimed to develop a sustainable EMP for a readymade garment factory and has important implications for promoting sustainability and achieving the Sustainable Development Goals (SDGs). Through the use of risk matrix analysis, the study identified noise pollution from various sources, such as winding and electricity generation, as well as water pollution from the washing section and air emission from the generator and boiler section, as the biggest environmental risks facing the factory. The findings of this study provide valuable insights into the environmental impact of the RMG industry and highlight the need for effective management strategies to address these challenges. The study has important implications for management and decision-makers in the RMG industry, emphasizing the importance of EMP to promote sustainability. The results of this study can be used to inform policies and strategies aimed at reducing the environmental impact of the industry and promoting sustainability.

This study is related to several SDGs, including SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), and SDG 12 (Responsible Consumption and Production). The effective management of environmental risks identified in this study can contribute to achieving these SDGs by promoting clean water and sanitation, affordable and clean energy, decent work and economic growth, and responsible consumption and production.

The study is not without limitations. The risk matrix analysis was limited to a single factory, and further research is needed to understand the environmental impact of the RMG industry on a larger scale. In addition, the study did not take into account the potential social and economic impacts of environmental management strategies, which are important considerations in decision-making. For future research, it would be beneficial to conduct a comprehensive analysis of the environmental impact of the RMG industry, including both the positive and negative effects. Additionally, further research is needed to explore the most effective management strategies for addressing the environmental risks identified in this study and promoting sustainability in the industry.

References

Abdin, M. D., Opportunities and challenges of the new industrial revolution. *Opportunities and Challenges of the New Industrial Revolution (November 26, 2017)*, 2017.

Ahmed, S. M., Karmaker, C. L., and Ahmed, M., Assessment of safety, health and environmental risk factors in garments industries of Bangladesh. *Journal of applied research on industrial engineering*, *6*(3), 161-176, 2019.

Ahmed, S. S., Akter, T., and Ma, Y., Green supply chain management (GSCM) performance implemented by the textile industry of Gazipur district, Dhaka. *Logistics*, *2*(4), 21, 2018.

Aktar, A., and Islam, Y., Green human resource management practices and employee engagement: Empirical evidence from RMG sector in Bangladesh. *Available at SSRN 3363860*, 2019.

Alexis, A. P. F., The Environmental Management Tools and Instruments of Application. *American Journal of Environmental Protection*, *10*(6), 120-126, 2021.

Baby, S., Approach in developing environmental management plan (EMP). In *Proceedings of the 2nd International Conference on Environmental Engineering and Application, Shanghai, China* (Vol. 253), 2011.

Bari, A. M., Siraj, M. T., Paul, S. K., and Khan, S. A., A Hybrid Multi-Criteria Decision-Making approach for analysing operational hazards in heavy fuel oil-based power plants. Decision Analytics Journal, 3, 100069, 2022.

Bristi, U., Rajib, M. I., and Shoukat, S., Implementation of corporate social responsibility in the ready-made garment industry of Bangladesh in order to achieve sustainable development goals: a study on Bangladeshi garment manufacturers. *Journal of Textile Science and Technology*, *6*(4), 232-246, 2020.

Chowdhury, F. Y., Keya, A. J., and Freelance Researcher, M. B. A., Readymade Garments Exports from Bangladesh: Challenges and Possible Way-Out. *International Journal of Business and Management*, *17*(7), 2022.

de Z Gunathilaka, L. F. D., and Gunewardena, K. D., An analysis of the corporate managers awareness towards the environment sustainability in apparel industry. *Journal of Medical and Bioengineering Vol*, *3*(2), 2014.

Gunasekara, W. A. D. P., *The Practice, Obstacles and Benefits of Voluntary Environment Management Accounting Practice in Green Adopted Apparel Manufacturing Enterprises in Sri Lanka: A Qualitative Research* (Doctoral dissertation, Sabaragamuwa University of Sri Lanka), 2020.

Hossen, M. M., Islam, R., and Tumpa, A. S., Can Green Management Practices Ensure Environmental Sustainability? A Firm-Level Study on Readymade Garments Sector of Bangladesh, 2021.

Ibrahim, N. A., Alwi, S. R. W., Manan, Z. A., Mustaffa, A. A., and Kidam, K., Risk matrix approach of extreme temperature and precipitation for renewable energy systems in Malaysia. *Energy*, *254*, 124471, 2022.

Ikwan, F., Sanders, D., and Hassan, M., Safety evaluation of leak in a storage tank using fault tree analysis and risk matrix analysis. *Journal of Loss Prevention in the Process Industries*, *73*, 104597, 2021.

Islam, T., and Halim, M. A., Impact of ready-made garments (RMG) industries and sustainability: Perspective of the pandemic period in developing country. *Cleaner Engineering and Technology*, *11*, 100567, 2022.

Khan, M. Z. H., Environmental management system of textile industry in Bangladesh: constraint and remediation. *International Jour of Environment, Ecology, Family and Urban Studies*, *7*(2), 1-12, 2017.

Kosma, C. I., Lambropoulou, D. A., and Albanis, T. A., Investigation of PPCPs in wastewater treatment plants in Greece: occurrence, removal and environmental risk assessment. *Science of the total environment*, *466*, 421-438, 2014.

Maanan, M., Saddik, M., Maanan, M., Chaibi, M., Assobhei, O., and Zourarah, B., Environmental and ecological risk assessment of heavy metals in sediments of Nador lagoon, Morocco. *Ecological Indicators*, *48*, 616-626, 2015.

Muhib, M. I., Khan, M. S. A., and Akter, R., RISK PRIORITIZATION OF ENVIRONMENTAL ASPECTS AND OCCUPATIONAL HEALTH SAFETY IN TEXTILE INDUSTRIES OF GAZIPUR INDUSTRIAL AREA, BANGLADESH. *Bangladesh Journal of Multidisciplinary Scientific Research*, *3*(2), 11-20, 2021.

Ni, H., Chen, A., and Chen, N., Some extensions on risk matrix approach. *Safety Science*, *48*(10), 1269-1278, 2010.

PART, A., and Waters, I. PART A. 9: ENVIRONMENTAL MANAGEMENT PLAN (EMP). *Assessment*, *1*(2189), 2021.

Patnaik, S., and Tshifularo, C. A., Management of wastes in garment manufacturing. In *Waste Management in the Fashion and Textile Industries* (pp. 83-97). Woodhead Publishing, 2021.

Rahman, I., and Dey, P., Corporate Sustainability Performance Benchmarking of Best Practicing Bangladeshi RMG Companies using Analytic Network Process (ANP). *Journal of Knowledge Globalization*, *13*(1), 2021.

Rahman, K. S., Implications of green management practices in the RMG industries of Bangladesh-an environmental sustainability perspective. *Int. J. Manag. Account*, *3*(6), 122-129, 2021.

Saha, P., Talapatra, S., Sá, J. C., and Santos, G., Impact of TQM and Industry 4.0 on Sustainable Performance: An Empirical Study on the Bangladeshi Garment Industry. In *Quality Innovation and Sustainability: 3rd ICQIS, Aveiro University, Portugal, May 3-4, 2022* (pp. 131-143). Cham: Springer International Publishing, 2023.

Shumon, R., and Rahman, S., Environmental Sustainability Requirements in the Ready-Made Garment Industry. In *Sustainable Approaches in Textiles and Fashion: Manufacturing Processes and Chemicals* (pp. 1-19). Singapore: Springer Singapore, 2022.

Siraj, M. T., Bari, A. M., Haq, M. M., and Al Islam, M. F., Prioritization of Fire Risk Remedial Actions in the Ready-Made Garment Industry of Bangladesh: A Hybrid MCDM Approach. *Proceedings of the 5th European International Conference on Industrial Engineering and Operations Management Rome, Italy,115-127, 2022a*

Siraj, M. T., Bari, A. M., Shahriar, M. H., and Al Islam, M. F., Prioritization of the Electrical Risk Factors in the Ready-Made Garment Industries of Bangladesh: A Hybrid MCDM Approach. *Proceedings of the 7th North American International Conference on Industrial Engineering and Operations Management, Orlando, Florida, USA, 165-177, 2022b*

Vishwakarma, A., Meena, M. L., Dangayach, G. S., and Gupta, S., Identification of challenges and practices of sustainability in Indian apparel and textile industries. In *Recent Advances in Industrial Production: Select Proceedings of ICEM 2020* (pp. 149-156). Springer Singapore, 2022.

Yang, Y., Yang, X., Xiao, Z., and Liu, Z., Digitalization and environmental performance: An empirical analysis of Chinese textile and apparel industry. *Journal of Cleaner Production*, *382*, 135338, 2023.

Youli, Y., Yingjian, P., and Xiaoxia, L., Research on safety risk management of civil construction projects based on risk matrix method. In *IOP Conference Series: Materials Science and Engineering* (Vol. 392, No. 6, p. 062080). IOP Publishing, 2018.

Zhang, X., and Dong, F. To participate or not? Research on second-hand apparel recycling intention under the guidance of environmental psychology. *Waste Management and Research*, 0734242X231151613, 2023.

Zor, S., Conservation or revolution? The sustainable transition of textile and apparel firms under the environmental regulation: Evidence from China. *Journal of Cleaner Production*, *382*, 135339, 2023.

Biographies

Md. Kamrul Hasan Chowdhury is a Boiler Safety Engineer at the RMG Sustainability Council, in Bangladesh. He completed his Bachelor in Mechanical Engineering at the Rajshahi University of Engineering and Technology, Bangladesh. He has several years of industry experience as an engineer. His research interests include Industrial Management, Safety Studies, and Environmental Sustainability.

Md. Tanvir Siraj is a graduate student in the department of Industrial and Production Engineering at the Bangladesh University of Engineering and Technology (BUET). He completed his Bachelor of Mechanical Engineering in 2016 from BUET. Currently, he is working as a Boiler Safety Engineer at RMG Sustainability Council, Bangladesh. His research interest includes Operations Research, Decision Science, Optimization, and Environmental Sustainability.

Nazrul Islam completed his Bachelor in Mechanical Engineering at the Rajshahi University of Engineering and Technology, Bangladesh. His research interests include Industrial Management, Safety Studies, and Environmental Sustainability.

Spandan Basak Payel is a Sub-divisional Engineer of Northern Electricity Supply Company Ltd., Bangladesh. He completed his Bachelor of Mechanical Engineering in 2016 from the Bangladesh University of Engineering and Technology (BUET). His research interest includes Waste Management, Operations Research, Decision Science, Optimization, and Environmental Sustainability.

Debashis Biswas completed his Bachelor's in Electrical Engineering at the National Institute of Technology, India. He has several years of RMG industry experience as an engineer. His research interests include Industrial Management, Safety Studies, and Environmental Sustainability.