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# Influencing Factor of Waste Generation towards Environmental Sustainability and Economic Viability

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**Abstract**

In today's rapidly evolving industrial landscape, the efficient management of industrial waste has become an imperative for both environmental sustainability and economic viability. This report explores the key factors that influence industrial waste generation and how the application of information technology and MIS is important in the minimizing waste management challenges. Industrial wates refer to those material which discarded or couldn't be used in manufacturing like excess raw material, broken or defective product. The manufacturing process could generate a huge amount of waste materials, ranging from dangerous chemicals to non-recyclable by products. This research utilizing both quantitative approaches, collect primary data through questionnaire and data collection instruments will be using Google form and qualitative approach, using secondary data from existing sources as supporting resources. This report has examined the key factors influencing industrial waste generation and emphasized the vital role of information technology and information systems in addressing waste management challenges. In addition, the foundation of equipment efficiency lies in regular maintenance protocols. Hence, implementing rigorous and proactive maintenance practices is essential to ensure that equipment remains in top condition.

**Keywords**

Waste Management, Environmental Sustainability and Economic Viability

## 1.0 Introduction

Due to the negative effect could bring to human health, the responsible waste management is essential which not only focus in reduce environmental pollution but also to adhere to stringent regulations and minimize operational costs. According to Research Nester, they have predicted that the global industrial waste management market will increase at a CAGR of 8% from 2022 to 2023 and the factor of market is due to the number increase of industries around the world and the cost of management have to increase to solve the need to manage waste more effectively.

So, the application of information technology and advance managing information system take an important role in the process. It has emerged as powerful tools in addressing these challenges, allows businesses to optimize waste management processes, increase the

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resource efficiency, and contribute to a greener to achieve sustainable future. For example, Internet of Thing (IoT) devices. Industrial garbage management businesses through IoT devices such as IP video cameras, to monitor hazardous waste sites, predict equipment needs, and plan for repairs. This data-driven approach minimizes the impact of repairs and maintenance on workers' daily activities, ensuring safety and efficiency in waste management. By leveraging data-driven insights, real-time monitoring, and intelligent decision-making, organizations can streamline their waste management practices and align them with global sustainability goals.

## 2.0 Literature Review

### 2.1 Social Factor

Waste takes on diverse forms and meanings, often varying from person to person (Ferronato & Torretta, 2019). For instance, individuals like waste pickers see "waste" as a potential income source (Fadhullah, Imran, Ismail, Jaafar, & Abdullah, 2022). In the realm of waste management, it's crucial to consider the social factors intertwined with these issues. Many researchers argue that the mismanagement of waste often arises from human behaviour, making the solution contingent on behavioural modifications (Raghu & Rodrigues, 2020).

Culture plays a pivotal role in aligning humanity with both its physical environment and societal norms. It helps us understand how cultural beliefs and practices can be integrated into environmental management programs to minimize waste. Establishing a green organizational culture can effectively reduce waste in manufacturing by setting continuous improvement goals for employees across processes, services, and products (Liu & Lin, 2020). For example, adopting lean manufacturing principles can eliminate unnecessary processes, thus minimizing waste (Kaneku-Orbegozo, Martinez-Palomino, Sotelo-Raffo, & Palomino, 2019). A green organizational culture necessitates embracing collectively shared values, perspectives, norms, and practices guiding every organizational level toward responsible waste reduction within the manufacturing industry.

In a study by Liu and Lin (2020), it was found that corporate social responsibility serves as a driver in achieving an environmental and social balance. Organizational culture becomes genuinely successful when led by employees who wholeheartedly support waste minimization. Therefore, a robust waste management culture is equally vital to engage employees at every level. This encompasses both environmental considerations and employee behaviour (Ercantan & Eyupoglu, 2022). While culture is important, so is employee behaviour. Pro-environmental behaviour among employees primarily hinges on their level of environmental consciousness (Nisar, et al., 2021). This heightened awareness fuels efforts to reduce waste, manage energy consumption, and promote recycling as part of a collective endeavour to mitigate environmental hazards. This perspective outlines a series of environmentally friendly activities within manufacturing industries contributing to the overarching goal of waste minimization.

Jahanshahi, Maghsoudi, & Shafighi (2021) have meticulously outlined a comprehensive framework for promoting green and environmentally friendly employee behaviour. This framework spans various environmental responsibilities, including increasing awareness of environmentally friendly practices, implementing green processes within manufacturing industries, and minimizing harmful environmental waste. For example, employees can make significant contributions by conserving energy, adopting double-sided printing for paper documents, utilizing email instead of paper communication, promoting document sharing through cloud platforms, and brainstorming ideas for waste reduction.

Mouro & Duarte (2021) have detailed pro-environmental behaviours as a set of rules and policies aimed at encouraging greater individual participation in addressing waste issues among manufacturing industries. However, stimulating employee engagement in environmental initiatives proves to be a multifaceted challenge (Albrecht, Bocks, Dalton, Lorigan, & Smith, 2021). In contrast to research on household waste reduction, limited exploration has been undertaken regarding employee behaviour aimed at waste minimization in the workplace.

## 2.2 Technical Factor

Technologies such as waste-to-energy, advanced sorting, digestion, and recycling enhance waste management, leading to more efficient and sustainable waste management practices (Jamal, 2020). In contemporary waste management, various waste treatment technologies are employed, utilizing materials, processes, and products to reduce the environmental impact of production (Mukherjee, et al., 2021). However, despite these advancements, some aspects of waste management processes still pose environmental risks. The primary impetus for minimizing waste lies in adding value to the entire supply chain, necessitating a shift from a linear economic model to a circular one (Brancoli, Bolton, & Eriksson, 2020). An exemplary transformation towards waste reduction has been observed in Industry 4.0, where digitalization plays a pivotal role (Javaid, Haleem, Singh, & Suman, 2021).

For instance, the NETWASTE survey has concluded that paperless order execution, electronic invoicing, and the use of service portals are expected to be utilized by over 60% of future waste disposal businesses in the manufacturing industry (Viswanathan & Telukdarie, 2022). The significance of material flow management in the manufacturing sector has been well-documented through the application of digitalization technology. As indicated by Abdelmajied (2022), Industry 4.0 aims to improve existing processes and material flows, reduce inventory damage, and minimize waiting times across the supply chain in the manufacturing industry.

Moreover, this aligns with the findings of Chauhan et al. (2022), which suggest that an intelligent manufacturing environment can enhance product lifecycles, reduce energy consumption, thereby reducing waste, promoting efficient resource utilization, recycling, and decreasing greenhouse gas emissions. The interaction between lean manufacturing and Industry 4.0, as identified by Taghavi & Beauregard (2020), has been found to have a positive impact on waste minimization, leading to cost reductions for organizations. Empirical studies in the literature have established a positive linkage between Industry 4.0 and lean management practices, as reported by Moraes, Carvalho, & Sampaio (2023). However, it is important to note, as highlighted by Sharma et al. (2020), that while Industry 4.0 offers significant achievements, its implementation is accompanied by numerous organizational and technological challenges.

## 2.3 Financial Factor

Recent attention has been directed towards the potential of incentive programs as drivers for waste reduction efforts. The availability of financial resources can affect the effectiveness of implementing a waste management system. (Jamal, 2020). In a 2019 study conducted by Struk, it was found that incentive programs have a positive impact on waste minimization in the manufacturing industry, significantly contributing to overall environmental improvements. Various forms of incentive programs, including rebates, cashbacks, coupons, communitybased reward systems, etc., exist. However, the preference for specific incentive types can vary from one country to another. In Struk's research also shed light on a crucial issue – the frequent misuse and neglect of economic incentives, despite their critical role in maintaining effective waste management systems. This underscores the necessity of developing a nuanced understanding of how these incentives are utilized.

From an economic perspective, pro-environmental behaviours are often framed as the "private provision of public goods" (Reiss, 2021). Unlike psychological theories, the economic approach assumes that individuals are driven by utility maximization, and their behaviour can be influenced through incentives. This is support by recent research by Asare et al. (2020) provides empirical support for this notion, a well-establishing waste reduction is indeed influenced by rewards and incentive systems instead of human behaviour. Furthermore, a study by Abila and Kantola in 2019 has reported a positive correlation between financial incentives and waste reduction and recycling. This body of evidence strongly indicates that rewards and rebates represent effective means of waste minimization within the manufacturing industry.

However, it is important that the effectiveness of these incentive programs is highly dependent on their proper implementation. It's not merely about having incentives in place, but also about ensuring that they are well-designed and thoughtfully integrated into waste management systems. Recently, in 2022, a study conducted by Asare, Oduro–Kwarteng, Donkora, & Rockson indicated that although incentive programs had been implemented for years in Italy, however, their efficiency levels of minimizing waste did not meet level of expectations. This suggests the need for ongoing development and enhancement of rules and regulations to address the specific challenges posed by environmental issue.

## 2.4 Industrial Waste Minimization

Waste minimization in household waste typically refers to individuals' actions aimed at reducing their contribution to the waste stream, such as reusing plastic bags or purchasing food and beverages in refillable containers (Mintz, Henn, Park, & Kurman, 2019). In terms of environmental impact, minimizing waste is often considered more effective than recycling (Purchase, et al., 2021). Waste minimization is influenced not only by environmental concerns but also by consumption habits and cost-saving efforts (Mintz, Henn, Park, & Kurman, 2019). Therefore, it can be assumed that waste minimization is strongly associated with environmental concerns.

From the perspective of the manufacturing industry, waste is defined as any activity or process that does not add value and is time-consuming. To eliminate waste, processes should retain only those elements that add value while eliminating those that do not add value (Ozgur Dogan & Simsek Yagli, 2019). According to (Leksic, Stefanic, & Veza, 2020), the adoption of lean principles should be supported by techniques such as kaizen, kanban, and 5S, as these waste management strategies can effectively reduce various types of waste in manufacturing and enhance the efficiency of lean processes. The literature demonstrates a strong connection between waste reduction in manufacturing and the implementation of lean tools in industrial processes, as supported by Purushothaman et al. (2020). This relationship is further elucidated by Sodhi et al. (2020), who emphasize the importance of lean methodologies in investigating work processes and reducing process duration caused by waste. The utilization of lean methods is essential in achieving a sustainable and green industrial environment through waste elimination (Vasconcelos, Viana, & Neto, 2019).

## 3.0 Research Methodology

According to the title of this research, its aim to investigate the factors influencing industrial waste reduction through the application of information technology and managing information systems. To achieve this, this report uses a mixed-method approach. The secondary data use existing literature, reports, articles, and academic studies related to industrial waste reduction and information technology will be reviewed. The sampling of this research will be employed to select 100 participants. The sample will include individuals from diverse industrial backgrounds and roles to ensure a comprehensive perspective. Questions will be designed to assess factors influencing industrial waste reduction, the effectiveness of information technology, and the role of information systems. A mix of demographic question, multiple-choice questions, will be included.

The statistical software (e.g., SPSS) will be use in the quantitative data collect through the questionnaire. In the SPSS report, the descriptive statistics to calculate the mean, median, and standard deviation and summarize responses such as demographic (department and position). At the same time, correlation statistics will be used to describe the relationship between two or more variables for one group of participants. Correlation is statistical tool that measures how strong relationship exists between variables (Sarad, 2019). The variables in this report including financial, technical and social factor. The uses of secondary data will provide support for the quantitative findings, helping to validate the research outcomes through using existing literature and secondary data will be reviewed and synthesized. The analysis of both primary and secondary data will draw the conclusions regarding the factors influencing industrial waste reduction through information technology.

By combining primary data from the questionnaire survey with secondary data from existing sources, this research aims to provide a comprehensive understanding of how information technology and information systems can be harnessed to minimize industrial waste effectively. The quantitative data will be supported and contextualized by insights from the existing body of knowledge in the field.

## 4.0 Data Analysis

### 4.1 Descriptive Analysis

The returned questionnaires from a sample size of 100 respondents consist of 47% male and 53% female, suggesting an evenly spread response in terms of gender. A majority of the respondents come from Manufacturing firm (66%) while 28% are in the Services line. The remaining 6% are from other firm types. 33% of the companies have operated for over 15 years while 29% have been operating between 6-10 years. Companies that have bee in operation for less than 5 years recorded 20% and 18% represents companies between 11-15 years of operation.


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**Position**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Executive | 27 | 27.0 | 27.0 | 27.0 |
| | Sr. Executive | 26 | 26.0 | 26.0 | 53.0 |
| | Asst. Manager | 18 | 18.0 | 18.0 | 71.0 |
| | Manager | 23 | 23.0 | 23.0 | 94.0 |
| | Sr. Manager | 6 | 6.0 | 6.0 | 100.0 |
| | Total | 100 | 100.0 | 100.0 | |

Table 4.1: Position Held in Company

Table 4.1 describes the position they hold in their respective company. Executive and Senior Executive level shared the same distribution with 27% and 26% respectively. Next will be the Manager level with 23%, followed by Assistant Manager (18%), and Senior Manager (6%). In terms of education level, Bachelor's Degree holders represent the highest percentage with 62%, followed by Master's Degree (21%), STPM/Diploma (11%), Cert/SPM (5%), and one sole representative with a PhD. Table 4.2 shows a majority (56%) of the respondents are working in the Manufacturing department as compared to 33% who are from the Operations department. Finance, HR, and Transportations department fills the gap with 6%, 5%, and 3% respectively.

**Department**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Operations | 30 | 30.0 | 30.0 | 30.0 |
| | Manufacturing | 56 | 56.0 | 56.0 | 86.0 |
| | Transportations | 3 | 3.0 | 3.0 | 89.0 |
| | Finance | 6 | 6.0 | 6.0 | 95.0 |
| | HR | 5 | 5.0 | 5.0 | 100.0 |
| | Total | 100 | 100.0 | 100.0 | |

Table 4.2: Respondents' Work Department

## 4.2 Cronbach's Alpha

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .932 | 4 |

Table 4.3: Cronbach's Alpha

Cronbach's Alpha is the most commonly used research method in testing the internal consistency (Sürücü et al., 2020). As shown by Table 4.3, the alpha value of .932 indicates that the internal consistency of the scale is high among the items that were being measured. According to Sürücü et al., (2020), "a Cronbach's alpha value of 0,7 and above is an indicator of the internal consistency of the scale." Therefore, the scale is considered reliable with the sample.

### 4.3 Multiple Regression Analysis

**Correlations**

| | | TDV | TFF | TTF | TSF |
|---|---|---|---|---|---|
| Pearson Correlation | TDV | 1.000 | .834 | .747 | .839 |
| | TFF | .834 | 1.000 | .750 | .795 |
| | TTF | .747 | .750 | 1.000 | .729 |
| | TSF | .839 | .795 | .729 | 1.000 |
| Sig. (1-tailed) | TDV | . | <.001 | <.001 | <.001 |
| | TFF | .000 | . | .000 | .000 |
| | TTF | .000 | .000 | . | .000 |
| | TSF | .000 | .000 | .000 | . |
| N | TDV | 100 | 100 | 100 | 100 |
| | TFF | 100 | 100 | 100 | 100 |
| | TTF | 100 | 100 | 100 | 100 |
| | TSF | 100 | 100 | 100 | 100 |

Table 4.4: Correlations Between the Variables

Based on the results of the Correlations in Table 4.4, all three independent variables (Financial, Technical, and Social Factors) correlate significantly with Minimizing Industrial Waste (.834, .747, and .839 respectively).

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | 95.0% Confidence Interval for B | | Correlations | | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound | Zero-order | Partial | Part | Tolerance | VIF |
| 1 | (Constant) | -.716 | .234 | | -3.061 | .003 | -1.180 | -.251 | | | | | |
| | TFF | .493 | .109 | .383 | 4.516 | <.001 | .276 | .709 | .834 | .419 | .212 | .306 | 3.268 |
| | TTF | .165 | .084 | .148 | 1.963 | .053 | -.002 | .331 | .747 | .196 | .092 | .389 | 2.569 |
| | TSF | .512 | .098 | .427 | 5.206 | <.001 | .317 | .708 | .839 | .469 | .245 | .328 | 3.048 |

a. Dependent Variable: TDV

Table 4.5: Collinearity Diagnostics

Based on Table 4.5, Tolerance value for Financial Factor (.306), Technical Factor (.389), and Social Factor (.328) are all above .01 which indicates that multicollinearity is not presence. Variance Inflation Factor (VIF) also supports that the multicollinearity assumption was not violated, with the value of 3.268 for Financial Factor, 2.569 for Technical Factor, and 3.048 for Social Factor, all below the cut-off of 10. As comparison of contribution among all the independent variables on the dependent variable (Minimizing Industrial Waste), Social Factor has the largest beta coefficient with .427, followed by Financial Factor with .383, and finally Technical Factor with .148. Significance level indicates that both Financial Factor (<.001) and Social Factor (<.001) made a unique and statistically significant contribution to Minimizing Industrial Waste, whereas Technical Factor (.053) did not make a significant unique contribution to the dependent variable.


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**Model Summary[b]**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .888[a] | .788 | .782 | .47715 |

a. Predictors: (Constant), TSF, TTF, TFF

b. Dependent Variable: TDV

Table 4.6: Summary of Variance in the Dependable Variable

In terms of the model summary in Table 4.6, the variance in minimizing industrial waste is 78.8% (converted from the value of .788 of the R Square). However, judging by the fact that this research involved a rather small sample, the Adjusted R Square (.782) of 78.2% will be used in this report as it provides a better estimate of the true population value. The result of this model reaches statistical significance (<.001) as described in Table 4.7.

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 81.364 | 3 | 27.121 | 119.123 | <.001[b] |
| | Residual | 21.857 | 96 | .228 | | |
| | Total | 103.220 | 99 | | | |

a. Dependent Variable: TDV

b. Predictors: (Constant), TSF, TTF, TFF

Table 4.7: Statistical Significance

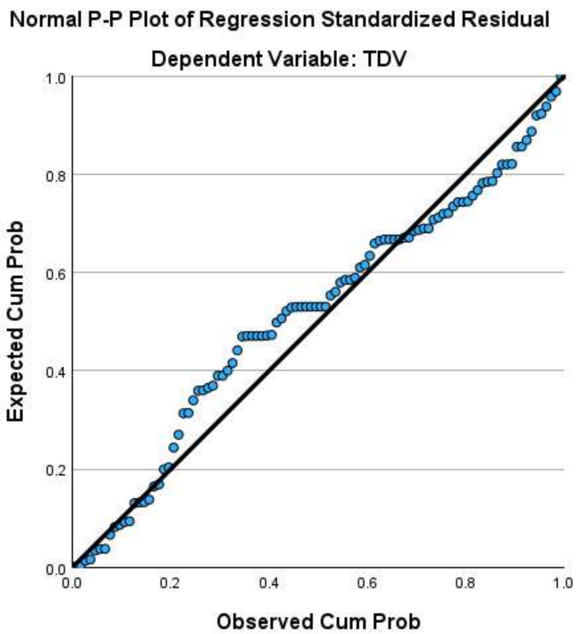


Figure 4.1: Normal Probability Plot

Based on Figure 4.1, the points are relatively close to a straight diagonal line from bottom left to top right, which indicates no major deviations from normality. Figure 4.2

indicated that most of the scores are concentrated in the center of the plot around the 0 point with minimal presence of outliers detected.

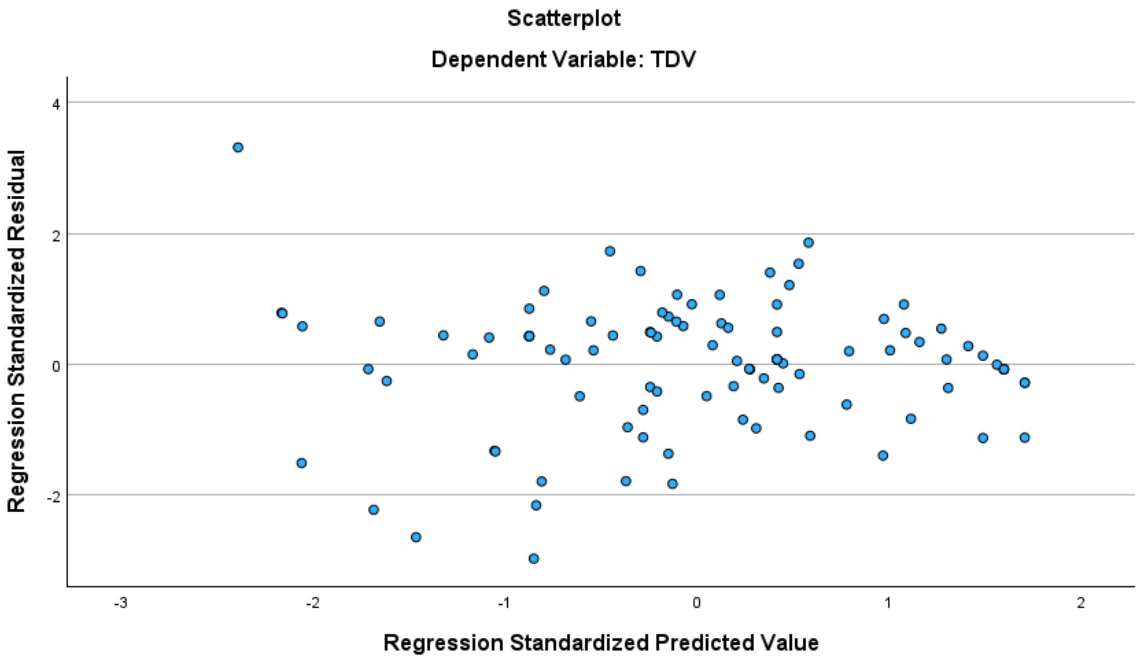


Figure 4.2: Standardized Residuals Scatterplot

## 5.0 Discussion

### 5.1 Social Factor

The findings indicate that social factor has the largest beta coefficient with .427 and a high level of statistical significance level (<.001) which appear the most significant contribution to minimizing industrial waste. Guo et al. (2021) have similarly emphasized that the management of solid waste is greatly impacted by social and economic aspects. The study of Knickmeyer (2020) also highlights the importance of taking into account the social factors at play in order to successfully adopt solid waste management (SWM). A sense of belonging and commitment to waste reduction goals which motivated employees are more likely to engage in sustainable practices. In order to improve the overall waste management system (WMS), a study was carried out to address the primary social issue with the current waste management system in Kabul city (Azimi et al., 2020). By actively prioritizing waste reduction in operations, businesses can drive meaningful change. Hence, social factor play a vital role in shaping sustainable waste management practices, covering cultural, behavioral, and collaborative dimensions.

### 5.2 Financial Factor

Based on the findings, the results indicate that financial factor has the beta coefficient with .383 and significance level (<.001) which appear the second significant contribution to minimizing industrial waste. The lack of funding will make it more difficult to implement the zero-waste concept because it calls for a complete transformation of the technologies used to manage and process recyclable solid waste, which requires significant funding at first to get started (Harun et al., 2019). It is crucial that having sufficient financial resources enables organizations to allocate funds for the promotion of waste reduction, recycling, and recovery programs. Nyampundu et al. (2020) also emphasized that lack of funding is one of the reasons why solid waste management policy, regulations, and norms are not implemented properly. These systems ensure that waste is handled, processed, and disposed of in accordance with regulations and industry best practices, reducing the risk of environmental violations and associated financial penalties. Therefore, financial factor also important to waste management in order to encompassing economic incentives, cost-effectiveness, and potential benefits from waste reduction.

## 5.3 Technical Factor

The findings indicate that technical factor has the beta coefficient with .148 and significance level (<.053) which less significant contribution to minimizing industrial waste throughout the respondents who majority came from manufacturing industry. Mohanty et al. (2022) argued that inadequate techniques and a lack of technical knowledge have produced a variety of waste categories. According to Lekšić et al. (2020), as the initial stages of implementing lean, it is advisable to utilize lean tools that reduce a variety of waste because they have a statistically significant positive effect on waste reduction. However, it seems like not applicable to whole manufacturing industry in Malaysia. A reviewed analysis done by Abu et al. (2019) stated that the furniture manufacturing in Malaysia is unlikely to benefit from lean manufacturing principles. Plus, implementation of the waste management facility may be hampered by a lack of comprehensive planning and national policy alignment (Chin et al., 2022). Throughout the respondents result outcome that indicate technical factor may less significant due to the limited sample size taken, but other developed country taking much considerations on this factor in waste management encompass various strategies and advancements aimed at reducing waste generation, improving resource efficiency, and enhancing environmental sustainability.

## 6.0 Recommendation

In today's era of Industry 4.0, technology plays a pivotal role in optimizing waste management operations. The integration of advanced technologies, such as sensors and automation, has the potential to revolutionize equipment efficiency (Sarc, et al., 2019). Modern machinery is made to be productive and efficient, which decreases the time and effort needed for trash removal and increases operating efficiency overall (Sarc, et al., 2019). Automated systems can efficiently sort and process waste materials, improving the overall efficiency of the process while minimizing the risk of human error. This not only saves time but also ensures that waste is managed with precision. The real-time data furnished by these systems empowers companies to respond promptly to any deviations from optimal performance, allowing for swift corrective actions.

Safety is another critical aspect, as up-to-date equipment incorporates advanced safety features, mitigating the risk of accidents and fostering a safer work environment (Alaloul, Liew, Zawawi, & Kennedy, 2020). Investments in modern waste management machinery not only strengthen a company's environmental reputation but also foster customer loyalty. This translates into long-term cost savings due to reduced operating expenses and heightened productivity (Zhao, et al., 2020). The adaptability of modern equipment to changing needs and the competitive advantage it affords in the market underscore its importance. By comparing performance to predetermined benchmarks, businesses may measure advancements over time and identify problems that might need fixing.

One of the key factors to achieve efficient waste management is essential for the modern manufacturing industry is having well-trained personnel. Well-trained staff can recognize subtle signs of malfunction or inefficiency, which can be addressed promptly, preventing costly breakdowns and operational disruptions (Ouyang, Li, & Du, 2020). By providing them with the skills to perform regular equipment inspections, organisations can proactively address issues before they escalate, ultimately contributing to overall operational efficiency. This includes instruction on cleaning, lubrication, parts replacement, and other preventive measures (Bag & Pretorius, 2020). It's important to empowering employee with the ability to perform these tasks ensures that equipment consistently operates at its peak, minimizing the need for major repairs and reducing downtime. Regular inspections allow for the early identification of issues, preventing potential breakdowns and operational disruptions. By conducting routine inspections, companies can address minor problems before they escalate into costly repairs or equipment failures. This not only prolongs the lifespan of the equipment but also contributes to enhanced overall operational efficiency.

## 7.0 Conclusion

In conclusion, efficient industrial waste management is imperative for both environmental sustainability and economic viability in today's industrial landscape. Social factors, encompassing organizational culture and employee behaviour, significantly shape sustainable waste practices, while financial factors, including funding and incentives, are crucial for effective waste management implementation. Although technical factors exhibited lesser significance in the Malaysian context, globally, advanced technology and lean principles play a vital role in waste reduction. To achieve efficient waste management, organizations should invest in technology, provide comprehensive training, and establish proactive maintenance practices, ultimately contributing to environmental responsibility and economic efficiency.

## References

Abdelmajied, F. Y. (2022). Industry 4.0 and Its Implications: Concept, Opportunities, and Future Directions. In T. Bányai, *Supply Chain - Recent Advances and New Perspectives in the Industry 4.0 Era.* IntechOpen.

Abila, B., & Kantola, J. (2019). The perceived role of financial incentives in promoting waste. *Recycling, 4*(4), 4. doi:https://doi.org/10.3390/recycling4010004

Abu, F., Gholami, H., Saman, M. Z. M., Zakuan, N., & Streimikiene, D. (2019). The implementation of lean manufacturing in the furniture industry: A review and analysis on the motives, barriers, challenges, and the applications. *Journal of Cleaner Production*, 234, 660–680. https://doi.org/10.1016/j.jclepro.2019.06.279

Albrecht, S. L., Bocks, A., Dalton, J., Lorigan, A., & Smith, A. (2021). Pro-Environmental Employee Engagement: The Influence of Pro-Environmental Organizational, Job and Personal Resources. *Sustainability 2022, 14*(1), 43. doi:https://doi.org/10.3390/su14010043

Alaloul, W. S., Liew, M. S., Zawawi, N. A., & Kennedy, I. B. (2020). Industrial Revolution 4.0 in the construction industry: Challenges and opportunities for stakeholders. *Civil Engineering, 11*, 225-2390. doi:https://doi.org/10.1016/j.asej.2019.08.010

Asare, W., Oduro-Kwarteng, S., Donkor, E., & Rockson, M. (2020). Recovery of municipal solid waste recyclables under different incentive schemes in Tamale. *Ghana Sustain 2020, 12*(1), 9869. doi:https://doi.org/10.3390/su12239869

Azimi, A. N., Dente, S. M., & Hashimoto, S. (2020). Analyzing waste management system alternatives for Kabul City, Afghanistan: considering social, environmental, and economic aspects. *Sustainability*, 12(23), 9872. https://doi.org/10.3390/su12239872

Bag, S., & Pretorius, J. H. (2020). Relationships between industry 4.0, sustainable manufacturing and circular economy: proposal of a research framework. *International Journal of Organizational Analysis, 13*, 1-35. doi:http://dx.doi.org/10.1108/IJOA-04-2020-2120

Brancoli, P., Bolton, K., & Eriksson, M. (2020). Environmental impacts of waste management and valorisation pathways for surplus bread in Sweden. *Waste Management, 117*(1), 136-145. doi:https://doi.org/10.1016/j.wasman.2020.07.043

Chandra Kafle, Sarad. (2019). *Correlation and Regression Analysis Using SPSS*. Retrive from:https://www.researchgate.net/publication/343282545_Correlation_and_Regression_Analysis_Using_SPSS

Chauhan, S., Singh, R., Gehlot, A., Akram, S. V., Twala, B., & Priyadarshi, N. (2022). Digitalization of Supply Chain Management with Industry 4.0 Enabling Technologies: A Sustainable Perspective. *Processes, 11*(1), 96. doi:http://dx.doi.org/10.3390/pr11010096

Cheng, J., Shi, F., Yi, J., & Fu, H. (2020). Analysis of the factors that affect the production of municipal solid waste in China. *Journal of Cleaner Production*, 259, 120808. https://doi.org/10.1016/j.jclepro.2020.120808

Chin, M. Y., Lee, C. T., & Woon, K. S. (2022). Policy-driven municipal solid waste management assessment using relative quadrant eco-efficiency: A case study in Malaysia. *Journal of Environmental Management*, 323, 116238. https://doi.org/10.1016/j.jenvman.2022.116238

Ercantan, O., & Eyupoglu, S. (2022). How Do Green Human Resource Management Practices Encourage Employees to Engage in Green Behavior? Perceptions of University Students as Prospective Employees. *Sustainability 2022, 14*(3). doi:https://doi.org/10.3390/su14031718

Fadhullah, W., Imran, N. I., Ismail, S. N., Jaafar, M. H., & Abdullah, H. (2022). Household solid waste management practices and perceptions among residents in the East Coast of Malaysia. *BMC Public Health 22, 1*(2022), 1-20. doi:https://doi.org/10.1186/s12889-021-12274-7

Ferronato, N., & Torretta, V. (2019). Waste Mismanagement in Developing Countries: A Review of Global Issues. *Int J Environ Res Public Health, 16*(6), 1060. doi:10.3390/ijerph16061060

Guo, W., Xi, B., Huang, C., Li, J., Tang, Z., Li, W., Ma, C., & Wu, W. (2021). Solid waste management in China: Policy and driving factors in 2004–2019. *Resources Conservation and Recycling*, 173, 105727. https://doi.org/10.1016/j.resconrec.2021.105727

Harun, H. A., Yunus, N. M., Rasul, R., Zainudin, A. Z., Zakaria, S. R. A., & Mohsin, A. (2019). Challenges in the implementation of zero waste concept in Johor Bahru city council. *International Journal of Real Estate Studies*, 13(1), 80-88.

How IoT Technologies Are Helping to Provide Industrial Waste Solutions | Lanner. (2018, January 26). Lanner. https://www.lanner-america.com/blog/iot-technologies-helping-provide-industrial-waste-solutions/

Industrial Waste Management Market Size & Share, Growth Analysis 2030. (n.d.). Industrial Waste Management Market Size & Share, Growth Analysis 2030. Retrive from: https://www.researchnester.com/reports/industrial-waste-management-market/3336

Jahanshahi, A. A., Maghsoudi, T., & Shafighi, N. (2021). Employees'environmentally responsible behavior: the critical role ofenvironmental justice perception. *SUSTAINABILITY: SCIENCE, PRACTICE AND POLICY, 17*(1), 1-14. doi:https://doi.org/10.1080/15487733.2020.1820701

Jamal, H. (2020). *Factors Affecting Solid Waste Management System*. Retrieved from https://www.aboutcivil.org/factors-affecting-solid-waste-management-system#:~:text=Technical%20Factors,-These%20factors%20include&text=Technologies%20such%20as%20waste%2Dto,and%20sustainable%20waste%20management%20practices.

Javaid, M., Haleem, A., Singh, R. P., & Suman, R. (2021). Significance of Quality 4.0 towards comprehensive enhancement in manufacturing sector. *Sensors International, 2*(1), 100109. doi:https://doi.org/10.1016/j.sintl.2021.100109

Kaneku-Orbegozo, J., Martinez-Palomino, J., Sotelo-Raffo, F., & Palomino, E. R. (2019). Applying Lean Manufacturing Principles to reduce waste and. *IOP Conf. Series: Materials Science and Engineering, 689*, 1-6. doi:10.1088/1757-899X/689/1/012020

Knickmeyer, D. (2020). Social factors influencing household waste separation: A literature review on good practices to improve the recycling performance of urban areas. *Journal of Cleaner Production*, 245, 118605. https://doi.org/10.1016/j.jclepro.2019.118605

Leksic, I., Stefanic, N., & Veza, I. (2020). The impact of using different lean manufacturing tools on waste reduction. *Advances in Production Engineering and Management, 15*(1), 81-92. doi:https://doi.org/10.14743/apem2020.1.351

Liu, X., & Lin, K.-L. (2020). Green Organizational Culture, Corporate Social Responsibility Implementation, and Food Safety. *Front. Psychol, 11*(2020), 1-7. doi:https://doi.org/10.3389/fpsyg.2020.585435

Mintz, K. K., Henn, L., Park, J., & Kurman, J. (2019). What predicts household waste management behaviors? Culture and type of behavior as moderators. *Resources, Conservation and Recycling, 145*(1), 11-18. doi:https://doi.org/10.1016/j.resconrec.2019.01.045

Mintz, K. K., Henn, L., Park, J., & Kurman, J. (2019). What predicts household waste management behaviors? Culture and type of behavior as moderators. *Resources, Conservation and Recycling, 145*(1), 11-18. doi:https://doi.org/10.1016/j.resconrec.2019.01.045

Mohanty, S., Saha, S., Santra, G. H., & Kumari, A. (2022). Future perspective of solid waste management strategy in India. *In Handbook of Solid Waste Management: Sustainability through Circular Econom*y (pp. 191-226). Singapore: Springer Nature Singapore.

Moraes, A., Carvalho, A. M., & Sampaio, P. (2023). Lean and Industry 4.0: A Review of the Relationship, Its Limitations, and the Path Ahead with Industry 5.0. *Machines, 11*(4), 443. doi:https://doi.org/10.1080/14783363.2022.2141107

Mouro, C., & Duarte, A. P. (2021). Organisational Climate and Pro-environmental Behaviours at Work: The Mediating Role of Personal Norms. *Front. Psychol, 12*, 1-9. doi:https://doi.org/10.3389/fpsyg.2021.635739

Mukherjee, A. G., Wanjari, U. R., Chakraborty, R., Renu, K., Vellingiri, B., George, A., . . . Gopalakrishnan, A. V. (2021). A review on modern and smart technologies for efficient waste disposal and management. *Journal of Environmental Management, 297*(1), 113347. doi:https://doi.org/10.1016/j.jenvman.2021.113347

Nisar, Q. A., Haider, S., Ali, F., Jamshed, S., Ryu, K., & Gill, S. S. (2021). Green human resource management practices and environmental performance in Malaysian green hotels: The role of green intellectual capital and pro-environmental behavior. *Journal of Cleaner Production, 311*(127504), 1-11. doi:https://doi.org/10.1016/j.jclepro.2021.127504

Nyampundu, K., Mwegoha, W. J. S., & Millanzi, W. C. (2020). Sustainable solid waste management Measures in Tanzania: an exploratory descriptive case study among vendors at Majengo market in Dodoma City. *BMC Public Health*, 20(1). https://doi.org/10.1186/s12889-020-08670-0

Ouyang, X., Li, Q., & Du, K. (2020). How does environmental regulation promote technological innovations in the industrial sector? Evidence from Chinese provincial panel data. *Energy Policy, 139*, 1-10. doi:https://doi.org/10.1016/j.enpol.2020.111310

Ozgur Dogan, N., & Simsek Yagli, B. (2019). *Value Stream Mapping: A Method That Makes the Waste in the Process Visible.* London: Lean Manufacturing and Six Sigma - Behind the Mask. doi:https://www.intechopen.com/chapters/66217

Purchase, C. K., Zulayq, D. M., O'Brien, B. T., Kowalewski, M. J., Berenjian, A., Tarighaleslami, A. H., & Seifan, a. M. (2021). Circular Economy of Construction and Demolition Waste: A Literature Review on Lessons, Challenges, and Benefits. *Materials (Basel),* 15(1), 76. doi:10.3390/ma15010076

Purushothaman, M., Seadon, J., & Moore, D. (2020). Waste reduction using lean tools in a multicultural environment. *Journal of Cleaner Production, 265*, 121681. doi:https://doi.org/10.1016/j.jclepro.2020.121681

Raghu, S. J., & Rodrigues, L. L. (2020). Behavioral aspects of solid waste management: A systematic review. *Journal of the Air & Waste Management Association , 70*(12), 1268-1302. doi:https://doi.org/10.1080/10962247.2020.1823524

Reiss, J. (2021). *Stanford Encyclopedia Of Philosophy.* Stanford: The Metaphysics Research Lab.

Sarc, R., Curtis, A., Kandlbauer, L., Khodier, K., Lorber, K. E., & Pomberger, R. (2019). Digitalisation and intelligent robotics in value chain of circular economy oriented waste management – A review. *Waste Management, 95*, 476-492. doi:https://doi.org/10.1016/j.wasman.2019.06.035

Sharma, M., Kamble, S., Mani, V., Sehrawat, R., Belhadi, A., & Sharma, V. (2020). Industry 4.0 adoption for sustainability in multi-tier manufacturing supply chain in emerging economie. *Journal of Cleaner Production, 281*(2), 125013. doi:https://doi.org/10.1016/j.jclepro.2020.125013

Sodhi, H., Singh, D., & Singh, B. (2020). A conceptual examination of lean, six sigma and lean six sigma models for managing waste in manufacturing SMEs". *World Journal of Science, Technology and Sustainable Development, 17*(1), 20-32. doi:https://doi.org/10.1108/WJSTSD-10-2019-0073

Sürücü, L. & Maslakçı, A. (2020). Validity and Reliability in Quantitative Research. *Business & Management Studies: An International Journal*, *8*(3), 694–726. https://doi.org/10.15295/bmij.v8i3.1540

Struk, M. (2019). Waste Management Incentive Programs and Municipal Finance. *7th International Conference on Sustainable Solid Waste Management* (pp. 1-9). Crete Island: Faculty of Economics and Administration. doi:https://www.researchgate.net/publication/334611460_Waste_Management_Incentive_Programs_and_Municipal_Finance

Taghavi, V., & Beauregard, Y. (2020). The Relationship between Lean and Industry 4.0: Literature Review. *5th North American Conference on Industrial Engineering and Operations Management* (pp. 808-820). Detroit: IEOM Society International.

Vasconcelos, D. C., Viana, F. E., & Neto, J. P. (2019). Lean and green: the contribution of lean production and environmental management to the waste reduction. *Revista de Administração da Universidade Federal de Santa Maria, 12*(2), 365-383. doi:https://www.redalyc.org/journal/2734/273460054011/html/#:~:text=Most%20respondents%20agree%20that%20the,of%20this%20model%20in%20their

Viswanathan, R., & Telukdarie, A. (2022). The role of 4IR technologies in waste management practices-a bibliographic analysis. *3rd International Conference on Industry 4.0 and Smart Manufacturing* (pp. 247–256). Johannesburg: Procedia Computer Science 200.

Zhao, L., Dai, T., Qiao, Z., Sun, P., Hao, J., & Yang, Y. (2020). Application of artificial intelligence to wastewater treatment: A bibliometric analysis and systematic review of technology, economy, management, and wastewater reuse. *Process Safety and Environmental Protection, 133*, 169-182. doi:https://doi.org/10.1016/j.psep.2019.11.014