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Impact Analysis of the Use of IoT Technology and Environmental Monitoring Systems on Waste Reduction in the Food and Beverage Industry in Indonesia

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ABSTRACT

The present research endeavors to examine the effects of IoT technology and environmental monitoring systems on waste reduction within Indonesia's food and beverage sector. Using a sample of 250 participants, a thorough study was carried out while accounting for the size, location, and kind of operation of the organization. Discriminant validity was verified after the measurement model underwent a thorough evaluation for validity and reliability. Tests of statistical significance demonstrated how important IoT technology and environmental monitoring systems are in affecting waste reduction. The model's significant explanatory and predictive power is demonstrated by the R-Square and Q2 values, while the model fit index highlights the estimated model's suitability. The results offer significant perspectives for industry participants and policy officials who seek to enhance sustainability measures in Indonesia's food and beverage industry.

Keywords: *IoT Technology, Environmental Monitoring Systems, Waste, F&B Industry, SEM PLS, Indonesia*

1. INTRODUCTION

Waste reduction and management provide issues for the food and beverage industry. Enzymatic bioprocessing holds the potential to transform industry waste and by-products like pomace and discarded grains into high-value components. These byproducts contribute to a more environmentally friendly and sustainable food system since they contain bioactive components that can be used in food applications [1]. One element that has been found to impair the financial success of food and beverage companies is weak corporate governance. Research has indicated that enhancing company governance, encompassing elements like board independence and composition, can improve returns on assets and financial performance [2], [3]. In order to offset the decline in sales in high-income countries, the food and beverage sectors have also been concentrating on prospects in low- and middle-income nations. This change in emphasis emphasizes the necessity of using strategic methods to deal with the issues the sector is facing [4].

Indonesia's food and beverage industry generates trash, which has an adverse effect on the environment. The nation's rapid industrialization and economic growth have exacerbated the sector's problems. The production of food crops has been strained by increased agricultural output brought on by elements including industrialization, land conversion, and climate change [5]. Furthermore, items related to palm oil dominate Indonesia's food industry, which has distorted the nation's global value chain dynamics in favor of forward connections with few backward linkages [6]. Furthermore, there is a clear and negative correlation between Indonesia's environmental quality and the success of its economic development initiatives as indicated by the country's Gross Regional Domestic Product (GRDP), particularly in the mining and quarrying industry [7]. These elements emphasize the necessity of sustainable practices and regulations in the food and beverage industry to lessen the negative effects of waste production on the environment and guarantee Indonesia's long-term food security. Reducing the industry's environmental effect and promoting sustainable business practices both depend on addressing these issues.

Indonesia's food and beverage sector has grown significantly as a result of rising urbanization and shifting consumer preferences. Growing waste has resulted from this expansion, posing issues for sustainability and the environment. Nonetheless, the potential of emerging technology to completely transform waste management procedures is becoming increasingly apparent [8]. Indonesia is a significant participant in Southeast Asia because of its rich natural resources and complex cultural legacy [9], [10]. Innovative solutions are required to efficiently manage and reduce trash in light of the problems presented by rising garbage levels. Utilizing new technologies can enhance waste management procedures, resulting in a strategy that is more ecologically friendly and sustainable [11].

The Internet of Things (IoT) is one exciting new technology for real-time data collecting and processing [12]. In order to support environmental monitoring systems, which provide cutting-edge instruments to evaluate and control environmental consequences, IoT incorporates smart devices and sensors [13]. These systems make use of Internet of Things technology to keep an eye on a number of variables, including waste management, water quality, and air quality [14], [15]. Multilevel and omnidirectional environmental monitoring functions can be accomplished by integrating IoT with GPS and GIS systems [16]. Real-time tracking and monitoring of environmental factors is made possible by the combination of IoT and electronic sensors, which lessens the strain of environmental monitoring staff and increases the accuracy of monitoring data. Furthermore, distributed data preprocessing, model training, and inference are made possible by the new edge computing paradigm, which enhances response latency, bandwidth utilization, and privacy for sensor-based AI systems. It is unclear, nevertheless, how much these technologies can really help reduce waste in the unique setting of Indonesia's food and beverage sector.

By performing a thorough investigation of the effects of IoT technologies and environmental monitoring systems on waste reduction in the Indonesian food and beverage industry, this research aims to close this knowledge gap. This research attempts to give useful insights for industrial stakeholders, policy makers, and environmental advocates by comprehending the efficacy of various technologies and identifying critical aspects that drive waste reduction.

2. LITERATURE REVIEW

2.1 Waste Reduction in the Food and Beverage Industry

The food and beverage industry faces significant challenges in waste management, requiring sustainable strategies to reduce waste and improve environmental and economic outcomes. Scholars have emphasized the importance of implementing effective waste reduction measures throughout the various stages of the industry, from raw material production to processing, packaging, and distribution [17], [18]. By adopting circular economy principles and promoting industrial symbiosis, businesses can minimize waste generation and maximize resource utilization [19]. This can be achieved through the establishment of collaborative platforms, such as the Upvalue marketplace, where companies can exchange waste and by-products [20]. Additionally, the implementation of sustainable waste management practices, such as recycling, reuse, and energy generation from waste, can contribute to environmental protection and economic development [21]. Overall, prioritizing sustainable waste reduction strategies in the food and beverage industry is crucial for minimizing environmental impact and ensuring long-term economic viability.

Studies in the field highlight the multifaceted nature of waste reduction, encompassing efforts to reduce both food and packaging waste. This literature emphasizes the interconnectedness of environmental, economic, and social dimensions in achieving comprehensive waste reduction goals within the food and beverage sector. Collaborative governance approaches, such as food policy councils (FPCs), have been identified as effective in engaging diverse stakeholders and organizations in food waste reduction efforts [22], [23]. These approaches foster collaboration, both internally and with external partners, to achieve policy and programmatic goals that individual stakeholders could not achieve alone [23], [24]. Additionally, sustainable packaging alternatives and optimizing recycling processes are crucial in significantly reducing packaging waste and promoting a more responsible and sustainable approach to food packaging [25]. Education, infrastructure, and policy change are also important strategies in combating food waste and creating a more sustainable and equitable food system. Furthermore, innovative waste processing techniques and stakeholder involvement play a significant role in constructing management indicators for foodservices and establishing waste management standards.

2.2 The Role of IoT Technology in Waste Reduction

The Internet of Things (IoT) has the potential to revolutionize waste management practices in the food and beverage industry. By integrating IoT devices, the industry can enhance traceability, reduce inefficiencies, and contribute to more sustainable production and distribution processes. IoT applications in this sector range from supply chain optimization to real-time monitoring of production processes and inventory management. These technologies enable data-driven decision-making, facilitating more efficient resource utilization and waste reduction. While existing literature showcases successful applications of IoT in waste reduction across various industries, there is a lack of research on its specific impact on the food and beverage sector in Indonesia. Further studies are needed to explore the nuances of IoT's influence on waste management practices in this particular context [26]–[28].

2.3 Environmental Monitoring Systems and Sustainability

Environmental monitoring systems are essent [12], [29] for assessing and managing the environmental impact of industrial activities. These systems provide tools for monitoring air and water quality, energy consumption, and waste generation, promoting sustainability, compliance with environmental regulations, and fostering a culture of corporate responsibility. The use of Internet of Things (IoT) technology is particularly suited for environmental monitoring, as it addresses challenges such as data gathering, handling, connectivity, and power utilization [30]. Additionally, the implementation of environmental management systems in organizations helps minimize environmental risks and increase competitiveness [31]. Electrochemical sensing platforms and chemical nanosensors are effective tools for detecting pollutants and monitoring environmental health [32]. Data compression algorithms can also be used to reduce energy consumption in wireless sensor nodes used for environmental monitoring. Overall, these advancements in environmental monitoring contribute to the protection of the environment, human health, and the achievement of sustainability goals. While there is a wealth of literature on environmental monitoring systems, their specific impact on waste reduction within the Indonesian food and beverage industry is an area that requires further exploration. Understanding how these systems contribute to sustainability goals and regulatory compliance is essential for designing effective waste reduction strategies.

Gaps in the Literature

The unique characteristics of the Indonesian food and beverage industry, shaped by cultural diversity, economic factors, and environmental challenges, require special focus [33]. Existing research outlines the trajectory of industry growth, challenges faced, and opportunities for sustainable development [34]. However, there is a lack of literature that delves into the intricacies of waste management practices and the potential impact of IoT technology and environmental monitoring [35]. While the reviewed literature provides valuable insights into waste reduction, IoT technology, environmental monitoring, and the food and beverage industry, there are still gaps [8]. Specifically, there is a need for research that systematically investigates the impact of IoT technology and environmental monitoring systems on waste reduction in the Indonesian food and beverage sector [36]. This research aims to fill this gap by providing empirical evidence and actionable insights for industry stakeholders and policymakers.

3. METHODS

3.1 Design and Sample

The influence of IoT technology and environmental monitoring systems on waste reduction in Indonesia's food and beverage industry is being investigated in this study using a quantitative research design. Purposive sampling, which selects samples based on predetermined criteria, and survey methodologies are used in this research design to gather and analyze numerical data in order to reach statistically significant conclusions. Applicants must: (1) work in the food and beverage sector; and (2) have experience implementing technology. (3) Taking part in programs to reduce trash. The study's target population comprises several industry participants involved in Indonesia's food and beverage sector, such as producers, distributors, and retailers.

For this investigation, a sample size of 250 individuals was used. As per Hair (2019), the sample size is adequate to attain statistical power and ensure practical feasibility in data collection and analysis with SEM-PLS. The decision was made to multiply the number of indicators by 5–10 times, as there are 9 total indicators in this study. This means that a minimum sample size of 90 is required. To guarantee that various scales and geographical areas within the food and beverage business were represented, a stratified random sample technique was employed. Stratification will be determined by variables including the size, location, and nature of the business.

3.2 Data Collection

Instrument

Information on the utilization of IoT technologies, environmental monitoring systems, waste reduction techniques, and environmental sustainability indicators was gathered using a standardized questionnaire. Likert scales and closed-ended items were both included in the questionnaire. The participants who had been identified were sent the questionnaire electronically. Participants received comprehensive instructions along with a description of the study's objectives. It was projected that four weeks would pass between September 30, 2023, and October 28, 2023, during the data collection period.

3.3 Data Analysis

Data analysis was done using Structural Equation Modeling with Partial Least Squares (SEM-PLS). SEM-PLS is an excellent tool for delving into intricate connections and interplays between variables in structural models. The software made it possible to thoroughly analyze the suggested conceptual framework and evaluate the connections between waste minimization, environmental sustainability, IoT technology, and environmental monitoring systems. The conceptual framework obtained from the literature review forms the basis for the development of the research model. Latent structures for waste reduction, environmental sustainability, environmental monitoring systems, and Internet of Things technology will be included in the model. Every construct has a measurement model that is established, and the structural model is examined to assess how the constructs relate to one another.

4. RESULTS AND DISCUSSION

Descriptive Statistics

A summary of the traits of the 250 participants from Indonesia's food and beverage industry may be found in the participant demographics section. In order to guarantee representation in several areas, such as company size, geography, and operating type, the sample was carefully chosen. There was good cross-industry diversity in the participation pool, with small businesses accounting for 32%, medium-sized businesses for 44%, and large businesses for 24%. This diversity guarantees a thorough comprehension of waste reduction strategies used by the food and beverage industry at different scales. Of the participant sample, 60% came from urban areas, while 40% was heavily represented by participants from rural areas. Because of this regional variation, waste reduction strategies influenced by both urban and rural contexts can be examined. A variety of operational contexts were represented in the participant sample; 36% worked in production, 32% in distribution, and another 32% in retail. A greater comprehension of waste reduction strategies unique to each operational segment is ensured by this stratification.

In this study, descriptive statistics for important factors are compiled. For the IoT technology utilization variable, the values were 4.2, 0.72, and 2.8-5 for the mean, standard deviation, and range, respectively. The environmental monitoring system variable had a mean of 3.9, a standard deviation of 0.62, and a range of 2.8–5 values. Lastly, the range, standard deviation, and mean for the waste reduction metric variable are 2.8–5, 0.82, and 4.1, respectively.

Validity and Reliability

If all item factor loadings are greater than 0.7 and the Cronbach's alpha values fall between 0.8 and 0.9, suggesting excellent internal consistency, then the measurement model demonstrates high validity and reliability.

Table 1. Measurement Model Test

Variable	Code	Loading Factor	Cronbach's Alpha	Composite Reliability	Average Variant Extracted
Use of IoT Technology	TI.1	0.886	0.905	0.940	0.840
	TI.2	0.936			
	TI.3	0.927			
Environmental Monitoring Systems	SPL.1	0.889	0.890	0.932	0.819
	SPL.2	0.992			
	SPL.3	0.904			
Waste Reduction	PL.1	0.917	0.882	0.927	0.809
	PL.2	0.903			
	PL.3	0.877			

Source: Data Processed by The Author (2023)

The factor loading of IoT technology is continuously high, exceeding 0.70, suggesting a good correlation between the latent construct and the observed indicators. Additionally, as evidenced by Cronbach's Alpha 0.70, Composite Reliability >0.80, and Average Variance Extracted scores >0.50, it demonstrates good internal consistency, reliability, and overall dependability. High factor loadings, internal consistency, validity, and dependability are other similar patterns found in the Waste Reduction and Environmental Monitoring System constructions. These results show that the Environmental Monitoring System and Waste Reduction's underlying ideas are successfully measured by the observable variables, and that these constructs are valid and dependable. The relationships between the constructs—Environmental Monitoring System, Waste Reduction, and IoT Technology—are shown in the correlation matrix that is supplied.

Table 2. Discriminant Validity

	Environmental Monitoring Systems	**Waste Reduction**	**Use of IoT Technology**
Waste Reduction	0.899		
Environmental Monitoring Systems	0.596	0.905	
Use of IoT Technology	0.686	0.589	0.917

Source: Data processed by the author (2023)

Moderately positive connections are shown by the correlation coefficients between the Environmental Monitoring System and Waste Reduction (0.596) and IoT Technology and Environmental Monitoring System (0.686)/Waste Reduction (0.589). These values show that these constructs are identifiable because they do not go above the 0.8 threshold. Because they are less than 0.8, the correlation coefficients in the matrix provide evidence for discriminant validity. This demonstrates that the three constructs—waste reduction, IoT technology, and environmental monitoring system—are unique and measure various fundamental ideas.

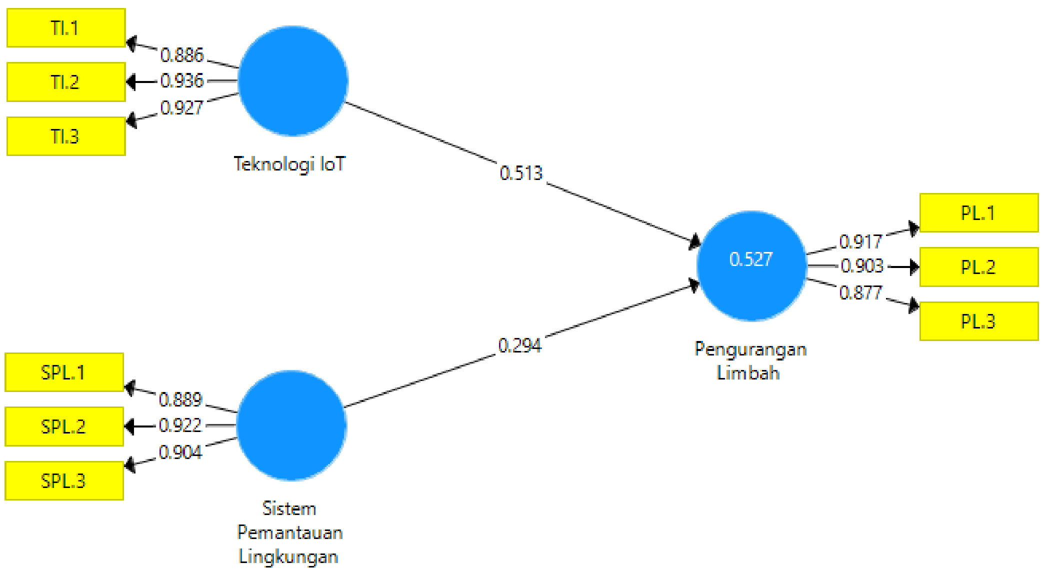

Figure 1. Internal Model Assessment

Model Fit Evaluation

Table 3. Model Fit Testing

	Saturated Model	**Estimated Model**
SRMR	0.058	0.058
d_ULS	0.153	0.153
d_G	0.143	0.143
Chi-Square	107.236	107.236
NFI	0.869	0.869

Source: Data Processed by The Author (2023)

The SRMR value (0.058) for the Full Model and the Estimated Model is the same, suggesting a good model fit. Additionally, both models have the same d_ULS value (0.153), which shows that the estimated and observed matrices suit each other well. In a similar vein, both models' d_G values (0.143) agreed, suggesting a good fit in replicating the observed covariance matrix. Both models' Chi-Square values (107.236) were the same, suggesting that the estimated model is a good approximation of the saturated model. Lastly, when compared to the null model, both models have the same NFI value (0.869), suggesting an acceptable match.

Table 4. Coefficient Model

	R Square	Q2
Waste Reduction	0.527	0.519

Source: Data Processed by The Author (2023)

With an R-Square value of 0.527, the independent variables in the model can account for roughly 52.7% of the variance in waste reduction. This suggests that the model does a decent job of explaining the dependent variable's variability. In contrast, the model has strong predictive relevance for waste reduction, as indicated by the Q2 score of 0.519. This indicates that the model may reasonably anticipate new, unseen data in addition to explaining the observed data.

Structural Model

The major links between variables are displayed by the structural model. Table 5 displays the path coefficients along with their significance levels.

Table 5. Hypothesis Testing

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
Environmental Monitoring System -> Waste Reduction	0.294	0.297	0.095	3.077	0.002
IoT Technology -> Waste Reduction	0.513	0.512	0.098	5.252	0.000

Source: Data Processed by The Author (2023)

Results from the t-test indicating a significant association between waste reduction and the environmental monitoring system were obtained. A p-value of 0.002 is linked to the t-statistic of 3.077, which is determined as the ratio of the difference between the sample mean and the original sample mean to the standard deviation. The statistical significance of the association between Waste Reduction and Environmental Monitoring System is demonstrated by the p-value, which is less than the widely accepted significance level of 0.05. Significant findings were also revealed by the t-test regarding the connection between IoT technology and waste reduction. IoT technology and waste reduction have a highly statistically significant link, as evidenced by the very low p-value of 0.000 and the t-statistic value of 5,252. Lastly, we offer a statement on the approved versions of our proposed hypotheses, which are H1 and H2.

Discussion

Together, the study's findings validate our theories and further knowledge of how IoT technology and environmental monitoring systems affect waste reduction in Indonesia's food and beverage sector. The significance of these technologies in promoting sustainable waste reduction practices is shown by the substantial R-Square and Q2 values, as well as the statistically significant link.

The correlation that exists between waste reduction activities and environmental monitoring systems is favorable, indicating the impact of environmental monitoring systems on waste reduction efforts. Similarly, the potential of IoT technology in optimizing waste reduction techniques is highlighted by the strong and extremely significant association between IoT technology and waste reduction. This is consistent with earlier studies. Systems for monitoring the environment are crucial to waste reduction efforts. In order to ensure the safety of the environment and people, these systems offer an effective and dependable method for monitoring pollutants and toxins in the environment [37]. However, there is a lot of room for improvement when it comes to waste reduction initiatives thanks to IoT technology. trash reduction procedures can be made more efficient by using IoT technology, which will result in a more ethical and sustainable approach to trash management [32], [38].

CONCLUSION

In summary, this study contributes to our understanding of the intricate relationships that exist between environmental monitoring, waste reduction, and technology adoption in the Indonesian food and beverage sector. The relevance of the link and the resilience of our measurement model highlight the role that IoT technology and Environmental Monitoring Systems play in promoting sustainable waste reduction strategies.

To maximize waste reduction efforts, our research emphasizes the need of embracing cutting-edge technology, especially the Internet of Things, and putting in place efficient environmental monitoring systems. The statistically significant association that has been established indicates the positive influence of these technologies and adds to the industry's broader conversation about sustainable practices.

Implications

Our findings highlight the potential of technology-based solutions to solve environmental concerns and have practical consequences for policy makers, industry players, and environmental advocates. Our research offers practical insights into how technology can help firms achieve significant waste reduction objectives, as more businesses place a higher priority on sustainability.

Limitations

Even though this study makes significant contributions, it is important to acknowledge its shortcomings. Future research should focus on the cross-sectional character of the data and the possible impact of unobserved variables. Our grasp of the changing waste reduction environment in the food and beverage industry can be further improved by longitudinal research and the addition of new elements.

Fundamentally, our study adds to the worldwide conversation on using technology to support sustainable practices by illuminating the unique context of trash reduction in Indonesia. The research's findings provide valuable insights for the industry as it continues to traverse the route towards environmental responsibility. These insights may be used to inform decision-making and strategically intervene in ways that support a more resilient and sustainable future.

REFERENCES

[1] P. Ashley-Norman and J. Bagenal, "Political complicity in junk food industry tactics," *Lancet*, vol. 401, no. 10393, pp. 2031–2032, 2023.

[2] O. O. Folorunso, S. A. Owolabi, and E. O. Ajike, "Corporate Governance and Return on Assets of Quoted Food and Beverage Firms in Nigeria," *J. Strateg. Manag.*, vol. 8, no. 1, pp. 58–72, 2023.

[3] R. A. Ezejiofor and E. C. Ezenwafor, "Corporate governance and tax avoidance: Evidence from Nigerian quoted food and beverage companies," *Macro Manag. Public Policies*, vol. 2, no. 4, pp. 40–47, 2020.

[4] I. Jakataofik, E. S. Paranita, and H. Ispriyahadi, "The Effect Of Company Financial Performance On Stock Prices With Dividend Payout Ratio As Intervening Variables In Food And Beverage Sector Companies," *Int. J. Sci. Technol. Manag.*, vol. 4, no. 2, pp. 474–491, 2023.

[5] A. Munir, "Climate Change and Food Insecurities: The Importance of Food Loss and Waste Reduction in Indonesia," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 2023, p. 12040.

[6] A. B. Setiawan, "Indonesian Food Production Challenges: Climate, Land and Industrialization," *JEJAK*, vol. 16, no. 1, 2023.

[7] I. Q. A'yun and S. Tiyaningsih, "The impact of economic development and density population on environmental quality in Indonesia," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 2023, p. 12013.

[8] L. A. Sihombing, S. Suharno, K. Kuleh, and T. Hidayati, "The Effect of Price and Product Quality on Consumer Purchasing Decisions through Brand Image," *Int. J. Financ. Econ. Bus.*, vol. 2, no. 1, pp. 44–60, 2023.

[9] S. D. Yubianto, "Understanding The Role of Local Culture and Local Food in Indonesia's Gastronomy Tourism," *J. Hosp. dan Pariwisata*, vol. 9, no. 1, 2023.

[10] S. A. Cahyono, C. Agus, S. A. S. Raharjo, A. W. Nugroho, and Y. Indrajaya, "Strategic tropical natural resources management and household socio-economic resilience due to the Covid-19 pandemic," in *Agricultural Bioeconomy*, Elsevier, 2023, pp. 167–182.

[11] T. A. Riyadi, "How Can Digital Transformation Take Part in Waste Management of Businesses in Indonesia?," *Int. J. Bus. Technol. Manag.*, vol. 4, no. 3, pp. 54–69, 2022.

[12] A. Kumar, H. Kim, and G. P. Hancke, "Environmental monitoring systems: A review," *IEEE Sens. J.*, vol. 13, no. 4, pp. 1329–1339, 2012.

[13] M. A. Makarem and M. A. Razaz, "Real-time big data analysis systems resulting from the Internet of Things (IoT)," 2023.

[14] L. Chen and L. Zhang, "Design of Ecological Environment Monitoring System Based on Internet of Things Technology," *Wirel. Commun. Mob. Comput.*, vol. 2022, 2022.

[15] S. R. Laha, B. K. Pattanayak, and S. Pattnaik, "Advancement of Environmental Monitoring System Using IoT and Sensor: A Comprehensive Analysis," *AIMS Environ. Sci.*, vol. 9, no. 6, pp. 771–800, 2022.

[16] G. Loseto *et al.*, "A Cloud-Edge Artificial Intelligence Framework for Sensor Networks," in *2023 9th International Workshop on Advances in Sensors and Interfaces (IWASI)*, IEEE, 2023, pp. 149–154.

[17] M. Soares *et al.*, "Challenges of Digital Waste Marketplace—The Upvalue Platform," *Sustainability*, vol. 15, no. 14, p. 11235, 2023.

[18] T. Kumari and A. S. Raghubanshi, "Waste management practices in the developing nations: challenges and opportunities," *Waste Manag. Resour. Recycl. Dev. World*, pp. 773–797, 2023.

[19] D. Yalçıntaş, S. Oğuz, E. Yaşa Özeltürkay, and M. Gülmez, "Bibliometric Analysis of Studies on Sustainable Waste Management," *Sustainability*, vol. 15, no. 2, p. 1414, 2023.

[20] X. Zhu *et al.*, "Effective multipurpose sewage sludge and food waste reduction strategies: A focus on recent advances and future perspectives," *Chemosphere*, vol. 311, p. 136670, 2023.

[21] R. R. Srivastava, D. K. Rajak, S. Ilyas, H. Kim, and P. Pathak, "Challenges, Regulations, and Case Studies on Sustainable Management of Industrial Waste," *Minerals*, vol. 13, no. 1, p. 51, 2022.

[22] G. Mahesh Kumar, A. Irshad, B. V Raghunath, and G. Rajarajan, "Waste management in food packaging industry," *Integr. Waste Manag. India Status Futur. Prospect. Environ. Sustain.*, pp. 265–277, 2016.

[23] N. Nadeau and E. A. Koebele, "Collaborating to reduce food waste: building collaborative advantage in local food systems," *Renew. Agric. Food Syst.*, vol. 38, p. e32, 2023.

[24] A. Taneja *et al.*, "Value Addition Employing Waste Bio-Materials in Environmental Remedies and Food Sector," *Metabolites*, vol. 13, no. 5, p. 624, 2023.

[25] C. Martin-Rios, C. Demen Meier, and S. Pasamar, "Sustainable waste management solutions for the foodservice industry: A Delphi study," *Waste Manag. Res.*, vol. 40, no. 9, pp. 1412–1423, 2022.

[26] R. Prakash and G. Singh, "GREEN INTERNET OF THINGS (G-IOT) FOR SUSTAINABLE ENVIRONMENT," *EPRA Int. J. Multidiscip. Res.*, vol. 9, no. 5, pp. 238–241, 2023.

[27] M. R. Kumar, B. R. Devi, K. Rangaswamy, M. Sangeetha, and K. V. R. Kumar, "IoT-Edge Computing for Efficient and Effective Information Process on Industrial Automation," in *2023 International Conference on Networking and Communications (ICNWC)*, IEEE, 2023, pp. 1–6.

[28] D. Gupta and P. Kulkarni, "Internet of Things (IOT) Driven Digital Transformation in BFSI Sector," in *2023 Somaiya International Conference on Technology and Information Management (SICTIM)*, IEEE, 2023, pp. 55–58.

[29] V. N. Dhamu, D. C. Poudyal, M. Samson, A. Paul, S. Muthukumar, and S. Prasad, "Environmental Biosensors for Agro-Safety Based on Electrochemical Sensing Mechanism with an Emphasis on Pesticide Screening," *ECS Sensors Plus*, 2023.

[30] O. Väänänen and T. Hämäläinen, "Linearity-based Sensor Data Online Compression Methods for Environmental Applications," in *2023 6th Conference on Cloud and Internet of Things (CIoT)*, IEEE, 2023, pp. 149–156.

[31] P. ŠVIKRUHOVÁ, M. ČEREŠ, Z. KAPSDORFEROVÁ, V. ZÁBOJNÍKOVÁ, and K. FRONC, "THE ENVIRONMENTAL MANAGEMENT ACTIVITIES AND SUSTAINABLE COMPETITIVE ADVANTAGE ON THE MARKET," 2023.

[32] S. Pandey and S. B. Mishra, "Chemical nanosensors for monitoring environmental pollution," *Appl. Nanotechnol.*

water Res., pp. 309–332, 2014.

[33] D. F. Utomo, C. Pahlevi, and F. R. Rahim, "The Effect of Sales Growth and Inflation Rate on Profit Changes in Food and Beverage Sub-Sector Manufacturing Companies Listed on The Indonesia Stock Exchange," *Int. J. Soc. Sci. Educ. Commun. Econ. (SINOMICS JOURNAL)*, vol. 2, no. 3, pp. 509–514, 2023.

[34] G. Widhiyoga, H. Wijayati, and R. Alma'unah, "Export Performance Of Indonesia's Leading Tropical Fruit Commodities To Main Destination Countries," *IQTISHADUNA J. Ilm. Ekon. Kita*, vol. 12, no. 1, pp. 128–148, 2023.

[35] A. L. Khairurrahman *et al.*, "Informative Industrial Analytic for Effective Retail Business Performance: A Case of Emerging Economy," *WSEAS Trans. Syst.*, vol. 22, pp. 170–179, 2023.

[36] L. Suzan and M. I. Putri, "The Effect of Intellectual Capital and Asset Management on Financial Performance," *JHSS (JOURNAL Humanit. Soc. Stud.*, vol. 7, no. 1, pp. 15–21, 2023.

[37] M. Aboughaly and I. M. R. Fattah, "Environmental Analysis, Monitoring, and Process Control Strategy for Reduction of Greenhouse Gaseous Emissions in Thermochemical Reactions," *Atmosphere (Basel).*, vol. 14, no. 4, p. 655, 2023.

[38] X. Zhong and Z. Chen, "Design and implementation of mobile monitoring system for storage environment based on Cortex-A53," in *2022 IEEE 5th International Conference on Information Systems and Computer Aided Education (ICISCAE)*, IEEE, 2022, pp. 894–899.