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"OPTIMIZATION OF IoT AND AI TOOLS: REAL-TIME WASTE DETECTION AND IT'S IMPACT ON PUBLIC HEALTH"

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OPTIMIZATION OF IoT AND AI TOOLS: REAL-TIME WASTE DETECTION AND IT'S IMPACT ON PUBLIC HEALTH

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Abstract: The purpose of the report is to propose an effective technological solution to tackle Bangladesh's waste management challenges using IoT sensors and AI for real-time waste monitoring to improve public health. A survey showed overwhelming concern and demonstrated almost the current disposal scheme: the majority considered it inadequate, citing pollution, garbage overspills, and health issues. The connection between unsafe waste disposal and illness was widely noted among respondents, motivating the use of sensor-equipped smart trash bins and AI-based monitoring solutions for managing waste flows and providing early alerts. Support for this solution was strong: 75.6% of the respondents were very likely to favor IoT and AI-based solutions if they could reduce health risks. Economic feasibility is also considered in the report: challenges such as implementation cost and public knowledge gaps were identified. For feasibility, the model prioritizes scalability and citizen engagement: smart bins would monitor fill levels and contents, transmitting data to an AI platform that optimizes collection routes and issues real-time alerts via a mobile app. Awareness campaign for proper waste segregation and health risks are recommended for support. A cost-effective hybrid model is therefore proposed, combining low-cost sensors with smartphone connectivity, initially operated in selected cities. Cumulatively, the findings suggested that IoT and AI integration into waste management can greatly enhance Bangladesh's environmental quality and public health, provided technical constraints, costs, and educational needs are addressed through gradual implementation and stakeholders' coordination.

Keywords: ***Smart waste management system, Real-time waste detection, Environmental pollution, Public health, Waste segregation, Smart bins, Artificial Intelligence, Internet of Things.***

1. INTRODUCTION

Waste management involves the processes associated with the collecting, transporting, processing, and disposal of waste in manners that create least negative effects on public health, the environment, and society. Nevertheless, due to the high rate of urbanization and industrialization, the conventional systems are increasingly failing in bringing sustainability and protecting public health.

In Bangladesh, the magnitude of the problem is severe. For instance, the country generates approximately 25,000 tonnes of solid waste daily [5]. Moreover, the survey projections indicate that medical waste could increase to as high as 50,000 tonnes yearly by the year 2025 [5]. Additionally, food waste from households is approximated at 14.10 million tonnes per year, representing a 19.4% leakage rate [8]. Moreover, electronic waste emerged as a critical problem with the generation of up to 2.7 million metric tonnes yearly [10]. Additionally, being the world's second-largest apparel producer Bangladesh produces as much as 577,000 metric tonnes of garment waste yearly.

Therefore, the nation is confronted with severe issues like environmental pollution, wasteful use of resources, and health hazards in the form of mosquito-borne infections. However, conventional waste management practices often fail because of lack of awareness, high costs, and insufficient technological expertise [2]. Therefore, it has become crucial to explore innovative solutions that can overcome these limitations. Within this framework, smart bins equipped with Internet of Things (IoT) capabilities and monitoring systems powered by Artificial Intelligence (AI) offer a viable alternative. These innovations are capable of facilitating real-time detection, automating waste classification, and advising citizens on appropriate disposal methods. Consequently, the current study seeks to explore how IoT

sensors and AI technologies be optimized for real-time detection and classification of waste in Bangladesh, and what impact would their adoption have on public health and environmental sustainability.

A. Hypothesis:

In this report, we aim to tackle Bangladesh's waste management system which has become increasingly critical due to rapid urbanization, population growth, and rising consumption patterns [6]. Since traditional disposal methods are proving inadequate, large volumes of solid, medical, food, and electronic waste are being mismanaged, thereby creating serious threats to both public health and the environment [7].

To overcome these challenges, we propose a smart waste management framework that integrates IoT-based smart bins with AI-powered data analysis. These smart bins, equipped with sensors and cameras, would continuously monitor fill levels, detect waste types, and transmit real-time information to a centralized platform [3]. By doing so, collection routes can be optimized, overflows prevented, and recycling initiatives will be strengthened [4].

Furthermore, the system is designed not only to improve efficiency but also to reduce overall operational costs. Ultimately, the purpose of this report is to design a cost-effective, intelligent, and socially inclusive waste management model that can transform existing practices, safeguard public health, and contribute to building a cleaner and more sustainable Bangladesh.

B. Literature Review:

Effective waste management forms the cornerstone of public health and the modern infrastructure. However, the developing nations particularly faces greater challenges regarding waste-related challenges, such as, excessive public bins, ineffective garbage collection systems, and a lack of sustainable policies [7]. Consequently, the growing amount of garbage enables the spread of diseases and pollution.

Fortunately, the integration of technology forms a promising path for progress. Specifically, the Internet of Things (IoT) and Artificial Intelligence (AI) provide tools to design more intelligent and effective systems. One notable IoT application is the creation of smart bins. These bins carry sensors that keep track of fill levels and report the data in real-time. Once the bin is full, the collection service receives an automatic notice and optimizes routes and schedules [2]. This data-centric method not only saves costs and fuels, besides avoiding public nuisance. Additionally, some proposed systems, such as a "Smart netbin" even offer users free internet to motivate them to dispose properly [3]. In the same manner, mobile apps play a significant role by delivering users real-time knowledge and reminders [4].

When it comes to waste segregation—the cornerstone of recycling—deep learning and AI are very effective. For example, Convolutional Neural Networks (CNNs) can be trained using image datasets to distinguish materials such as plastic, glass, or metal. Moreover, a suggested system (iSSWMs) implements the VGG-19 model and uses a camera to segregate garbage on a conveyor belt with 99.7% effectiveness, following which actuators sort it into designated bins [1]. Another model implements proximity sensors; for instance, the inductive sensor identifies metal whereas the capacitive sensor identifies plastic [2]. Waste not identified is then classified as non-metal. Finally, the automatic pre-sorting thereby facilitates the recycling process easier by ensuring the materials are separated prior to them getting mixed.

2. MATERIALS AND METHODS SECTION

- ***Required Materials:***

A sequential Survey tool (questionnaire) was prepared by using google forms. Devices Like: smartphone, Laptop, computer was used to prepare and share the questionnaire form. In order to store survey data, the responses were sent to Microsoft Excel. Some of the published research articles were also considered, to know about current status of the plan. Software generated by using Programming Languages like: Python, Java etc. and models created by Data Structure were used in order to classify harmful wastes, organic wastes as well as recyclable wastes.

- ***Methods Applied:***

This research was mainly conducted online by a questionnaire form (Surrey). With the help of these questions, current waste management issues, public health concerns, suggestions for better waste management was evaluated. For this questionnaire respondents of profession like: teachers, professors, students, IT engineers, doctors waste collectors etc. of different age group were selected.

Steps taken for data collection:

A questionnaire form containing 15 questions was sent to more than 60 people via social media platforms like: Facebook, Messenger, WhatsApp etc. A total of 45 responses were received. Within 7 days, collection of data was completed. The purpose of the research paper was informed to the participants using this text: "Please provide your valuable opinion by Participating this survey conducted on- How IoT sensors and AI can be optimized for real-time detection of waste in Bangladesh and what

impact does this have on public health."

Steps taken for storing data:

The data, that was collected by using Google Forms was directly exported to Microsoft Excel. This helped to store data sequentially in a structured manner. In responses, age group and profession of respondents were also stored which helped to compare and distinguish opinions of people according to their age and profession.

Processing of Data:

Both primary and secondary data were collected and both qualitative and quantitative approaches were used to analyze the obtained data. For collected responses, graphs generated in google forms were considered and described clearly in result and discussion section. In order to avoid incomplete responses all questions were made required. As a result of proper organization, it became reliable and easier to ready data for further analysis.

Applications of technology:

IoT based smart bins to detect fill level of waste bins and type of wastes thrown inside waste bins. Again, sensors fitted in the waste bins that alert people when hazardous or harmful waste substance gets disposed in wrong manner or in wrong bin and also help to classify wastes in real-time into organic, recyclables and hazardous items. An app named "SafeDisposalBD" programmed to send notifications and sms alerts on how to dispose harmful substances like needles, broken glass pieces, blades, chemicals etc. so that the waste collectors don't get hurt or infected. AI Software installed in this app would instruct citizens on proper disposal of wastes at proper places.

3. RESULT

The figures and tables obtained from the survey results are as follows:-

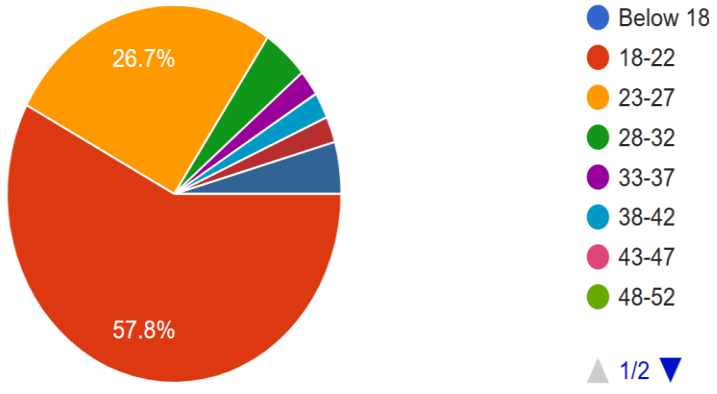

Fig:1- Age Group Distribution of Survey Respondents.

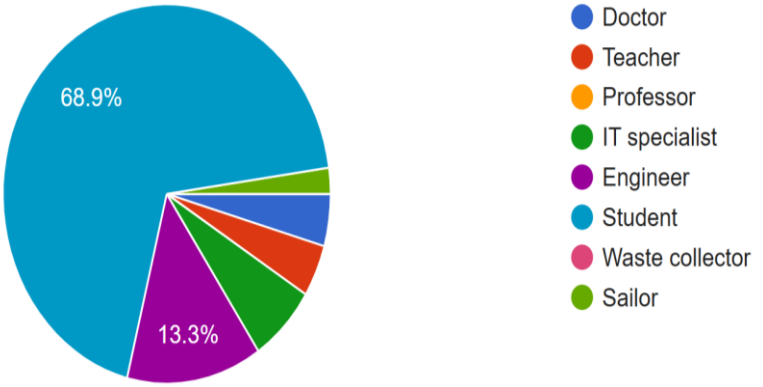

Fig:2- Profession Distribution of Survey Respondents

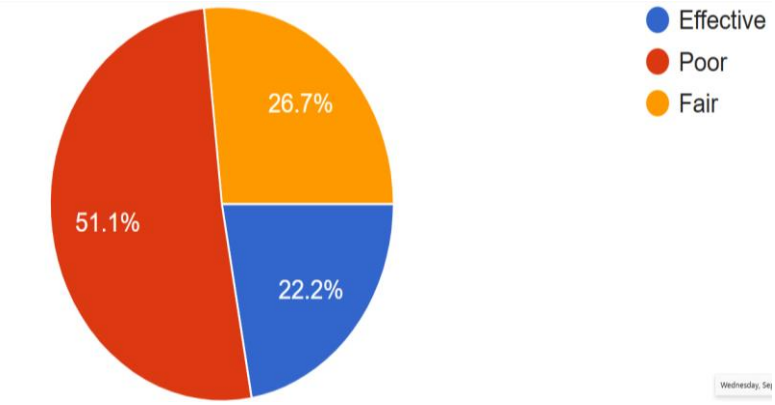

Fig:3- Respondent Assessment of Current Waste Management System

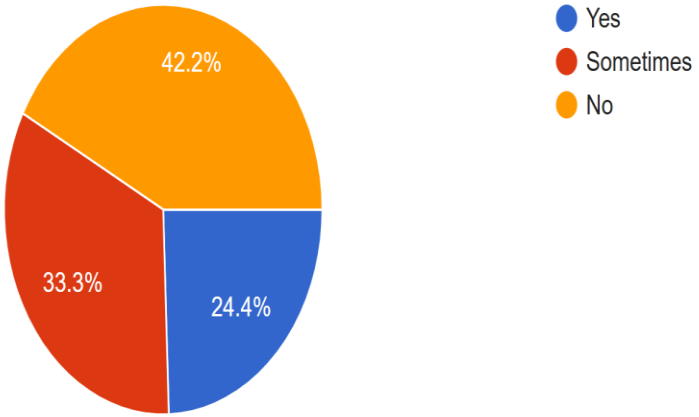

Fig:4- Perception of Waste Segregation Practices in Bangladesh

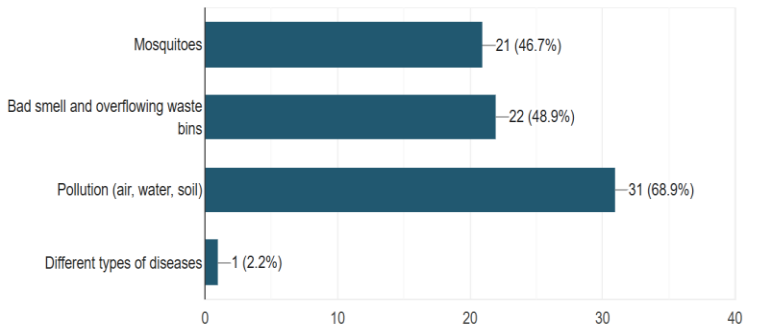

Fig:5- Problems caused due to improper waste management

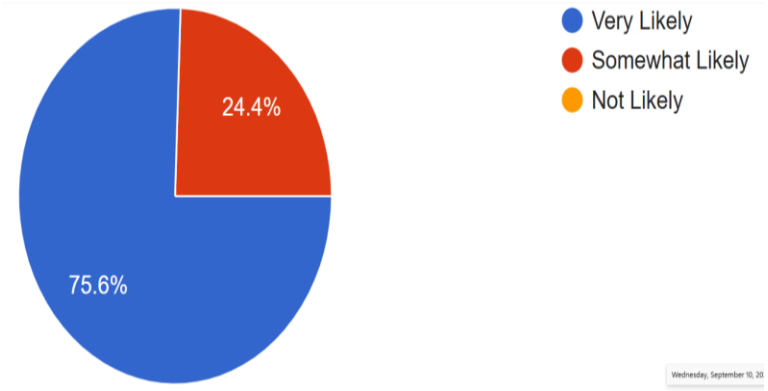

Fig:6- Support for a Smart Waste Management System

Table-1: Challenges of implementing IoT and AI in Bangladesh's waste management

Challenges	Percentage
High cost of technology	32.39%
Lack of awareness among citizens	36.62%
Lack of technical skills or maintenance	30.99%

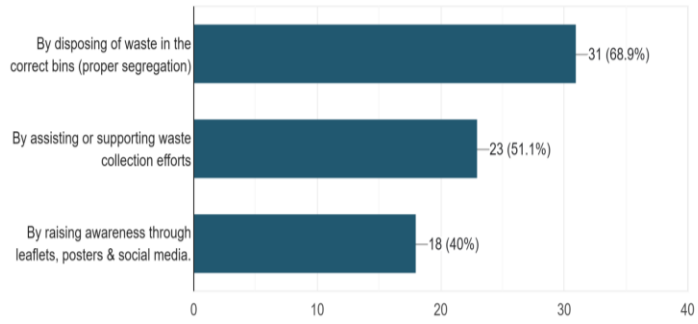

Fig:7- Citizen Contributions to Better Waste Management through Technology

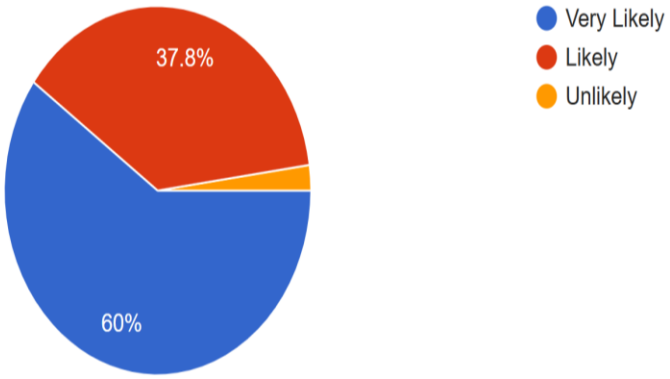

Fig:8- Public Support for the Implementation of IoT and AI Smart Bins

The results show public opinions on Bangladesh's waste management and their interest in using a smart waste management system to overcome existing problems. Fig.1 indicates age group distribution of survey respondents where majority of the survey respondents were young adults, with 57.8% falling into the 18-22 age group and 26.7% in the 23-27 age group. A small percentage of participants were from 28-32 and other age groups. Fig.2 shows that the survey also captured the professions of the participants, revealing that students constituted the largest group at 68.9%. Fig.3 represents perceptions of the current system which were largely unfavorable as nearly half of the respondents (51.1%) described waste management as poor with a mere 22.2% rating it as effective. It can clearly be seen that satisfaction with the existing system was low, as only a small fraction of respondents rated it effective. The survey participants broadly recognized that poor waste disposal practices harmed public health. On the other hand, from Fig.4, it becomes clear that the practice of waste segregation was also found to be lacking with 42.2% of respondents believing it was not practiced properly in Bangladesh. When asked about the types of problems caused by improper waste management, the responds stated in Fig.5 indicate most caused problems were different kinds of pollution (68.9%), bad smell and overflowing waste bins (48.9%) and mosquitoes (46.7%). A small percentage (2.2%) reported different types of diseases. The survey results revealed strong public support for a technology-based solution to waste management issues. Fig.6 shows that when asked how likely people would be to support a smart waste system if it could reduce health hazards, 75.6% of respondents said they were very likely to support it. Support for such a system grew sharply among the respondents with an additional 24.4% being somewhat likely. Despite this optimism, respondents highlighted key obstacles. From Table-1, lack of citizen awareness was cited by 36.62% as the most pressing challenge. This was followed by the high cost of technology (32.39%) and the lack of technical skills or maintenance (30.99%). In case of Fig.7, the most popular response was proper waste segregation (68.9%), followed by assisting or supporting waste collection efforts (51.1%) and raising awareness through various media (40%). A continuous slight rise in support for these methods over this time period was observed among the respondents. Fig.8 illustrates, when asked specifically about IoT and AI smart bins, there was a sharp rise with 60% of respondents stating that they would be very likely to support their introduction in their area, with an additional 37.8% saying they would be likely to support it. Basically, the results of the survey provided substantial evidence that the current waste management system in Bangladesh was perceived as inefficient and that this inefficiency caused significant environmental and health problems. The findings showed that a sharp rise in diseases

was a major concern for most of the respondents, who believed that improper waste disposal had a direct impact on public health. The survey also confirmed strong public support for a smart waste management system indicating they were very likely to support such an initiative.

To sum up, the survey results showed that the lack of public awareness, along with the high cost of technology and limited technical skills, posed the greatest challenges to implementing the smart waste management system. Nevertheless, the overall sentiment regarding the introduction of a new system was positive. Therefore, the hypothesis was proven to a mixed degree: while the public strongly believes an effective e-waste management system would be helpful, the report acknowledges that the high project cost of implementing IoT components and the lack of awareness among citizens remain major challenges.

4. DISCUSSION

The results show that the hypothesis was validated in part. It was particularly supported. From the findings mentioned in Fig.1, a dramatic change was observed as 57.8% of respondents were in between 18-22 years old, while the participation of senior citizens was notably low, which showed a decreased amount of responses from older age groups. Fig.2 represents that 68.9% of the respondents were students whereas 13.3% were engineers. This created a clear deviation from the expected balanced professional representation.

Fig.3 shows the state of current waste management system, 51.1% considered it to be poor, 26.7% considered it to be fair and only 22.2% considered it to be effective, which resembles public dissatisfaction with the current waste management system. Moreover, Fig.4 indicates the perception of waste segregation practices in Bangladesh where 42.2% responded negatively and marked that waste segregation practice is improper in Bangladesh. Fig.5 highlights that 68.9% of respondents recognized pollution as a major issue and 48.9% identified bad smell, overflowing of waste bins and 46.7% identified mosquitoes to be major issue, whereas, only 2.2% directly linked waste to diseases which is a surprisingly low figure that deviated from scientific evidences of strong health risks.

As a result of these challenges, support for smart systems was very strong which gets visible in Fig.6, with 75.6% being very likely, and 24.4% somewhat likely to adopt IoT and AI solutions.

Table-1 represents the challenges of implementing IoT and AI in Bangladesh's waste management system. In case of challenges that could hinder the implementation smart waste management system badly, 32.39% considered high cost to be the barrier, 36.62% indicated lack of awareness and 30.99% highlighted limited technical skill to be the barrier that can be caused in implementing this idea. This shows though public enthusiasm is high, successful implementation will depend on addressing these practical limitations.

So from the above analysis, we can explain, while there was broad support for the introduction of smart waste management system. The responses also marked several practical challenges, that could hinder implementation.

Though the study presented overall success of the proposed hypothesis, it also revealed major barriers, particularly the high costs that would be required for applying technology related solutions. This mixed outcome overall highlights the complexity and demonstrates that the transition to a technology based waste management system in Bangladesh is promising, yet not without critical challenges.

One of the most striking insights was the sharp increase in the number of younger respondents, especially the students, who displayed a clear willingness to adopt and support technology, whereas decrease in number of engagement of senior respondents may become the core reason of obstacle in emerging technologies.

Another significant observation was the perception of the existing waste management system as largely ineffective. Respondents described visible issues like mosquitoes, overflowing bins and bad smell as major inconveniences and ignored diseases that may occur due to improper waste disposal. This indicates that public tends to notice immediate and tangible problems of improper waste management system, while the associated health risks were overlooked.

The enthusiastic support for digital features such as: mobile applications and real-time monitoring smart bins suggest that technology could act as a catalyst to reform the current waste management system. As expected, people are open to integrating technology into everyday routines. However, cost concerns and lack of awareness were cited as most prominent obstacles. These responses underline the need for designing solutions that are cost-effective, user-friendly as well as adaptable to the socio-economic context of Bangladesh. These issues are similar to broader findings from some developing nations, where high setup expenses and unawareness of citizens often delay adoption [2].

From wider perspective, these findings relate to global research that identifies IoT and AI driven waste monitoring

has great potential and act as powerful tools, but requires higher technical skills, expensive accessories and public engagement [2]. Inadequate waste management can pose serious health risks, including infectious diseases [11].

Previous studies highlighted significant challenges and opportunities in solid waste management systems like: sustainability in developing countries is often hindered by inadequate infrastructure and public participation. Moreover, IoT and AI solutions demonstrated potential to enhance system performance, though lack of public awareness, required technical skills and financial costs remain major barriers [2].

However, according to the context of Bangladesh, while the appetite for application of technological solution is high, social and financial capacity lag behind. This imbalance creates both challenge and opportunity. On one hand, without sufficient support and public awareness, advanced systems may not achieve their full potential. On the other hand, the waste related health risks create ground for initiating experimental projects.

To sum up, the study demonstrates that smart waste management systems are both desirable and potentially ensuring health benefits, but challenges like financial cost and awareness gaps remain significant and thus, the hypothesis partially contradicted.

To conclude, while IoT and AI have the capacity to revolutionize waste practices but technology alone cannot solve this issue. The involvement of citizens, government agencies and non-government organizations are equally essential. Therefore, the success of smart waste management system would not only rely to investment but also on active participation of people.

Future studies may expand these findings by exploring smart systems, assessing their performance in real conditions, and piloting strategies to make them accessible and affordable for all.

5. CONCLUSION AND RECOMMENDATION

The findings of this study underscore the pressing need for comprehensive reform in Bangladesh's waste management system.

The current system has been widely perceived as inadequate by the majority of survey respondents, who highlighted recurring problems such as environmental pollution, overflowing waste bins, and foul odors. These visible challenges illustrate that existing waste disposal mechanisms are struggling to cope with the growing demands of a rapidly urbanizing population.

Although public awareness regarding the direct health risks associated with improper waste management remains limited, many respondents did recognize its indirect consequences, particularly the potential spread of communicable diseases and broader public health concerns. This indicates a partial but growing consciousness among citizens that waste management is not merely an environmental issue, but also a critical determinant of health and well-being.

The study also revealed strong public support for technology-driven solutions, particularly the adoption of Internet of Things (IoT)-enabled smart bins and artificial intelligence (AI)-assisted monitoring systems.

This indicates a high level of readiness among citizens to embrace innovative practices that could streamline collection, monitoring, and disposal processes. However, despite the enthusiasm for modernization, several formidable barriers emerged. These include the high cost of implementation, the lack of public education on smart systems, and limited technical expertise to operate and maintain advanced technologies. Collectively, these factors reduce the feasibility of immediate large-scale deployment and highlight the complexities involved in transitioning from a traditional to a technologically advanced waste management framework. Thus, while the potential benefits of such innovations are undeniable, their realization will require careful planning, phased implementation, and the involvement of multiple stakeholders. In light of these findings, several recommendations can be proposed.

First, public awareness and education campaigns should be prioritized to enhance citizen understanding of waste segregation practices and the long-term health consequences of improper disposal. Educated communities are more likely to actively participate in sustainable practices, thereby strengthening the effectiveness of waste management systems.

Second, both government and private sectors should collaborate to design cost-effective pilot projects, particularly in urban centers, to test the efficiency of IoT and AI-based solutions on a smaller scale before considering nationwide implementation. Such pilot projects can serve as learning models that identify strengths, weaknesses, and opportunities for scaling up.

Third, capacity-building programs must be introduced to train municipal staff, waste collectors, and technical

personnel in operating and maintaining smart waste systems. This will not only ensure proper functionality but also guarantee long-term sustainability.

Additionally, strategic partnerships between government bodies, non-governmental organizations, and technology providers are essential to mobilize resources, foster innovation, and bridge gaps in expertise.

In conclusion, the integration of IoT and AI represents a highly promising pathway for modernizing Bangladesh's waste management system. However, its success will depend on a balanced approach that combines technological innovation with social readiness, financial feasibility, and educational initiatives. Only through coordinated, collective efforts can Bangladesh achieve a sustainable, efficient, and health-conscious waste management system that aligns with the needs of its people and the demands of a modern urban society.

6. REFERENCES:

[1] A. Alourani, M. U. Ashraf, and M. Aloraini, "Smart waste management and classification system using advanced IoT and AI technologies", *Peer Computer Science*, vol. 11, e2777, Apr. 2025. [Online]. Available: https://doi.org/10.7717/peerj-cs.2777.

[2] T. Kadus, P. Nirmal, and K. Kulkarni, "Smart Waste Management System using IOT", *International Journal of Engineering Research & Technology (IJERT)*, vol. 9, no. 4, Apr. 2020. [Online]. Available: http://www.ijert.org

[3] M. A. Rahman et al., "Smart Trash Distribution, and Recycling Processes Using IoT Sensing & Mobile Application", in *Proc. 2nd International Conference on Computing Advancements (ICCA 2022)*, Dhaka, Bangladesh, Mar. 2022, pp. 6. [Online]. Available: https://doi.org/10.1145/3542954.3542988

[4] F. Montasir and A. I. Riad, "Leveraging AI and IoT for Sustainable Waste Management: A Framework for Bangladesh", *7th Int. Conf. on Advances in Civil Engineering (ICACE 2024)*, Chattogram, Bangladesh, Dec. 12–14, 2024. [Online]. Available: https://icace2024.cuet.ac.bd

[5] *Dhaka Tribune*, "Hospital waste management in Bangladesh lags," Jul. 2024. [Online]. Available: https://www.dhakatribune.com/bangladesh/373802/hospital-waste-management-in-bangladesh-lags. [Accessed Sept.12, 2025]

[6] Daily Country Today, "Hospital waste management lags behind sustainable standards," Jul. 2024. [Online]. Available: https://www.dailycountrytodaybd.com/story/hospital-waste-management-in-bangladesh-lags-behind-sustainable-standards. [Accessed Sept.12, 2025]

[7] The Finance Today, "Toxic medical waste mismanagement puts public health at risk," Jul. 2024. [Online]. Available: https://www.thefinancetoday.net/article/national/28859/Toxic-medical-waste-mismanagement-puts-public-health-at-risk. [Accessed Sept.12, 2025]

[8] Dhaka Tribune, "Bangladeshis waste more food than Americans," Feb. 2024. [Online]. Available: https://www.dhakatribune.com/bangladesh/342902/report-bangladeshis-waste-food-more-than-us. [Accessed Sept.12, 2025]

[9] M. A. Hossain, S. M. Rahman, and M. S. Rahman, "E-waste management in Bangladesh," arXiv preprint arXiv:1809.10021, 2018. [Online]. Available: https://arxiv.org/abs/1809.10021. [Accessed Sept.12, 2025]

[10] Reuters, "Textile giant Bangladesh pushed to recycle more waste," Apr. 2025. [Online]. Available: https://www.reuters.com/world/asia-pacific/textile-giant-bangladesh-pushed-recycle-more-waste-2025-04-23/. [Accessed Sept.12, 2025]

[11] World Health Organization, *Safe health-care waste management*, WHO, Aug. 2004. [Online]. Available: https://iris.who.int/bitstream/handle/10665/68776/a85189_eng.pdf?sequence=1. [Accessed Sept.12, 2025]

APENDIX

Link of survey questionnaire:

https://docs.google.com/forms/d/e/1FAIpQLSe8sjFREgYUkJjBOO-g4Dy_iaEN5hi6ZSf4ABel_qFcK3BN3w/viewform?usp=dialog

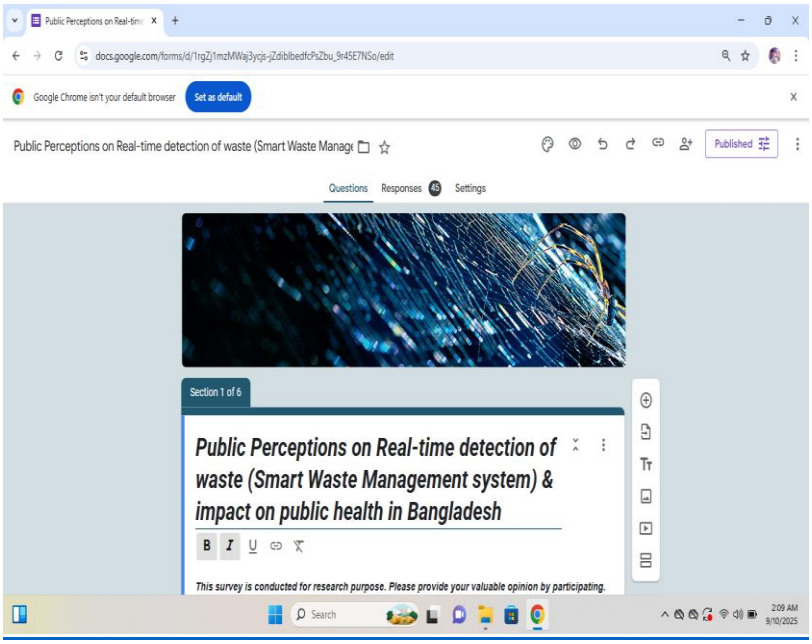

Fig:1- Screenshot of layout and title of survey form.

Fig:2- Screenshot of number of responses in survey form