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Waste Management and Recycling System with E- Money Rewarding System

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Abstract:- Waste management is a challenge in most developing nations. In 2021, cities around the world produced 11 billion tons of solid trash annually, or 3.85 kg per person, per day. It goes without saying that this number will more than double by 2025 to 33 billion tons (MT) due to urbanization and rapid population development. The inquiry has therefore revealed several issues, some of which include a lack of poor garbage collection methods, and a general lack of support for waste management from public. In this regard, it makes suggestions for increasing the efficiency of garbage collection by granting recycling companies direct access to waste owners. The public's involvement is crucial, and it should be kept in mind that this is not a task that can be completed with a single operation. As an encouragement for waste owners, we have suggested an e-money rewarding method for them. To recycle the trash in a way that doesn't harm society or the environment, a new waste management paradigm is needed. Alternative waste management strategy like converting waste to recycled products and rewarding with coins where people can eventually use that money to buy recycled items, the nation's current waste management strategy should be further expanded to pave the way for increased sustainability.

***Keywords**:- Waste Management, Segregation, Zero Waste and Sustainability, IOT.*

I. INTRODUCTION

Solid waste management (SWM) is a key issue that needs to be tackled in a priority way due to the rapid population growth and increase in garbage in expanding countries. Even while the quantity and quality of solid waste produced by metropolitan areas in developing countries are smaller than those of Western developed and industrialized countries, particularly in the west, municipal solid waste management is still insufficient in these regions [1].

However, industrialized nations continue to use a range of methods to handle issues, including composting, landfilling, and waste-to-energy processes. In this context, it makes sense to consider the approaches taken to fix the issue. Any material obtained for "primary use" or with "useless defects" for "subsistence use" is regarded as trash. Solid waste (SW), usually referred to as "trash," includes garbage from streets, shops, and factories as well as undesired and discarded things from residences. The creation of solid waste is influenced by both the quick change in lifestyle and the growing urban population. Solid waste is often heterogeneous in composition; as an illustration, garbage may comprise fruits, vegetables, food items, paper, plastics, rags, and glass. Trash may be valuable to one person but useless to another, and the ecosystem, ground water, and human health are all negatively impacted by the on-land, open-air disposal of solid waste [2]. A "waste problem" wouldn't exist in the world if it were feasible to turn "waste" into value.

Most nations in the world, particularly developing nations, struggle with how to effectively manage solid waste on their soils. It has been causing a variety of issues, including infections, intolerable odors, fire risks, water and air pollution, aesthetic annoyances, along with social and financial losses. There have been numerous sad instances of waste dumps collapsing in several nations, including Ethiopia and Sri Lanka. Many have argued that developing nations lack the necessary technology and that the biggest shortcomings in SW management in these nations are due to poor management and leadership.

The amount of rubbish being produced globally is rising. A nation's trash production is inversely correlated with its population and average living levels [3].

Additionally, Medina (1997) noted a strong correlation between waste generation rates and people's income levels. In addition, socioeconomic factors including the number of people per home, cultural norms, educational attainment, and individual attitudes are important [4]. In 2021, cities around the world produced 11 billion tons of solid trash annually, or 3.85 kg per person, per day. It goes without saying that this number will more than double by 2025 to 33 billion tons (MT) due to urbanization and rapid population development. By that time, we'll probably increase from 3.5 MTs to 6 MTs every day if the current trends hold. Around 70 BT of waste are produced in South Asia each year, with daily waste production rates per person ranging from 0.12 to 5.1 kg on average. According to Rachel et al. (2009), urbanization, population increase, low standards of living, a lack of environmental consciousness, and insufficient management of environmental information are all factors contributing to the continued indiscriminate disposal of SW, which is

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accelerating. Over the next twenty years, trash creation rates in low-income countries, however, will more than quadruple.

The handling of trash has historically raised serious issues about human health and safety, but today's society has higher expectations than in the past. Incorporating feedback loops, concentrating on processes, embodying adaptability, and preventing garbage from being disposed of are all characteristics of sustainable waste management, which society demands. Environmental concern has been a key factor in this sustainable system's policy decision-making process. To turn a conventional, unsustainable system into a sustainable one for waste management, one must recognize and use levers that cause change [5]. Failure to do so could result in poorly conceived solutions that could not be sufficient to produce any useful and long-lasting waste management results. Consequently, a system is needed to manage the creation, storage, collection, transportation or transfer, processing, and disposal of solid waste materials in a way that best considers a range of environmental factors, including public health, conservation, economics, aesthetics, engineering, and others.

II. II. LITERATURE REVIEW

A. Research Papers

The most recent study in this field was done by Zavare and his colleagues [6] using sensor nodes connected to an Arduino board-based control station that uses a GSM module to send data from the sensor nodes by SMS to the garbage collection vehicle and to a server hosting web applications by a Wi-Fi connection. The sensor nodes of the smart bins use the ultrasonic sensor to calculate the percentage of fullness based on previously computed bin depth. The location of the bin is also determined using a GPS module. The GPS module and the ultrasonic sensor are controlled by the Amica R2 Node MCU microcontroller board, which also connects to the control station via a built-in Wi-Fi module. Another [7] endeavor is the wireless sensor network study of Singh, Mahajan, and Bagai. In his research, the bins feature accelerometer sensors to monitor lid opening and closing, temperature and humidity sensors to monitor the presence of organic waste, and ultrasonic sensors to monitor the degree of bin filling. The Wi-Fi module built inside the Zigbee Pro microcontroller board that controls all these sensors is utilized to send sensor data to a gateway. This study's gateway utilized the same kind of microcontroller board to gather data from the bins and send it over GPRS to a control station that has a server. Server at the control station uses Caspio, a web-based database management system.

In a paper by Navghane, Killedar, and Rohokale [8], the authors investigated using a weight sensor and three IR sensors to track the degree of fullness in a smart bin and transmit the sensor data to a web page through Wi-Fi for mobile devices. In this investigation, an ARM LPC2148 microcontroller board was utilized.

B. Commercial and Industrial Solutions

Several businesses sell intelligent trash cans that are controlled by a web application. Smart garbage compactor bins are available from ECUBE labs [9] [10] and Bigbelly and they are powered by a solar cell panel and battery. Both the Clean CUBE and Bigbelly [11], smart garbage cans use ultrasonic and laser sensors, respectively, to determine when they are full [9] [10]. Additionally, most businesses provide IoT sensors that are simple to put on readily available garbage cans. These ultrasonic Internet of Things sensors are available in batterypowered models from ECUBE labs [10], ENEVO [12]. and SMARTBIN [13] Additionally, CUBE labs provide a solar powered one. However, COMPOLOGY [14] provides an IoT sensor that employs a camera to determine if massive industrial waste containers are full or not. To detect vandalism, fire, trash collection, and usage events, most of these Internet of Things sensors and smart bins have temperature, tilt, and acceleration sensors. To transmit data from IoT sensors and bins to their cloud-hosted web-application gateway over the internet, all these solutions employ cellular networks. These webapplications track trash collection efficiency by keeping an eye on fullness levels, energy use, fire warnings, and providing realtime readings, historical reports, as well as scheduling and routes. Finally, this study tries to cut costs by providing fullness alerts without the use of an internet connection or online apps, in contrast to the options already stated.

Since, Existing systems does not provide the functionality to make direct communication with the waste collecting companies and the waste owners does not get any sort of reward for their contribution we suggest below mentioned methodology to address those shortcomings of existing system.

III. III. METHODOLOGY

A. Tools and Technologies

This section describes how technology was used to get the intended output in a cost effective and efficient manner. Since this system must go through many requests from clients, we decided to use a tech stack which supported asynchronous functionality which saves clients from long waiting times. MERN [15] and MEAN were among our top choices because of popularity and community support, but we decided to go with MERN stack since we had prior experience with React. MERN stands for MongoDB, Express, React and NodeJs respectively. It is tech stack commonly used for web development. MongoDB is a document-oriented database which allows flexibility in every manner. All our data were stored in this database and retrieved by servers which ran on NodeJS with the help of Express framework. JWT tokens were used for user authentication and passwords were stored after being encrypted using bcrypt with an added salt to enhance the security. JWT secrets, bcrypt salt round numbers, database connection strings and all sensitive information were stored in env files and security precations were followed to prevent them being leaked to outsiders. Front end was developed with React which is a JS library for creating UI components. Redux was used for state management. react-bootstrap was used to get UI components. (1-8 paragraphs)

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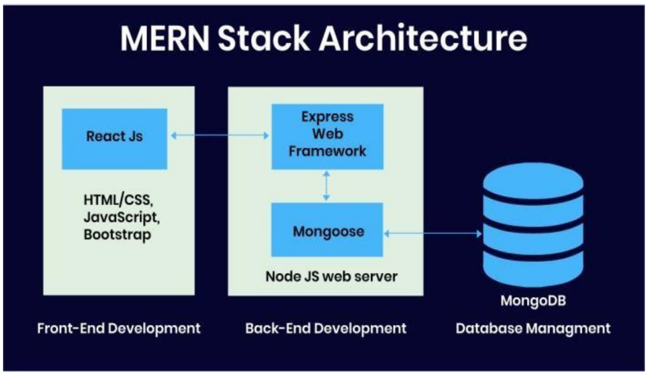

Fig1: MERN Stack Architecture

B. Hardware Requirements

Proposed system requires

- CPU: Core 2 duo or above
- RAM: 4 GB Ram
- Minimum Display Resolution: 1024 x 768
- Disk Space: 12 GB

C. Backend process related to main functionalities of this system

The work was done using a serverless methodology. The backend was decided to be MongoDB, and to communicate with the database and backend, we used the widely used mongoose library in the MERN stack. To submit photographs of the garbage collection firms, we also employed Firebase data storage. MongoDB is a NoSQL database that saves data as key-value pairs. JSON-formatted data generated in the frontend will be transmitted to the backend and with the aid of the mongoose library, the Express.js server processes the data retrieved and stores that data in MongoDB.

D. Main Frontend functionalities

To develop frontend of our application with a responsive nature we have used React which is a popular JS library used for frontend functionalities, and React Bootstrap, JSX, CSS is mostly used for designing of frontend of this system.

React allows developers to implement large scale web applications where their UI is adjusted when developers change the app's state.

➢ *Features of React,*

- Usage of virtual DOM, and Components.
- One-way Data binding.
- Simplicity due to usage of JSX
- Extended with Flux, Redux, React Native, etc. which helps us to create good-looking UI.

Also, to achieve the addition of map location for bins we used google map API as well.

E. Designing

Business analysts gather information prior to system development, and designers create UI, databases, class diagrams, and communication diagrams in accordance with those requirements to aid with the logical design of the system to be implemented.

The logical design is constructed using data flow diagrams and database design. setting the design specifications, which make clear what the potential system should be. In a class diagram upper part is used to specify the attribute which is to define a certain entity and lower part is used to specify the action performed by that entity. Class diagram is used to develop the backend of the system where each class is model in backend.

➢ *Class diagram*

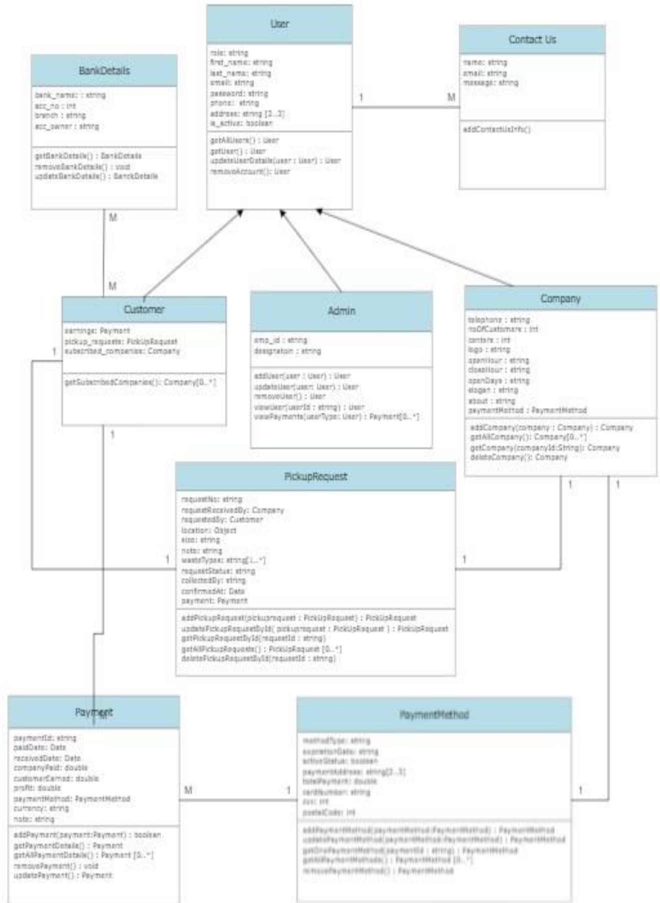

Fig 2: Class diagram

F. Testing

Each module is subjected to unit testing as part of the system testing process to make sure it performs as planned. The system is tested for its full functioning using integration testing as well as other techniques, making it more efficient. In this instance, automation testing was conducted using Selenium. Selenium, which is open source and free, is widely used to automate tasks. Test automation has been significantly impacted by Selenium. Its many useful capabilities include the capacity to record and replay web application test runs as well as the ability to run numerous scripts in various browsers.

This project's development also made use of other technologies. One such service that may be used to schedule and monitor the progress of software projects is Azure Boards. A team should have resources that can adjust at its disposal. Azure Boards does this, to put it simply, by providing a wide range of features like dashboard personalization, integrated reporting, and Scrum and Kanban integration. Git was used to facilitate collaboration and communication among programmers working on the same or different portions of the source code. This is done in collaboration with SonarQube. Sonar Source created this opensource framework to perform automatic code quality evaluations. Sonar does static code analysis and generates a detailed report of errors, code smells, security holes, and duplicate lines of code.

IV. IV. PROPSED SYSTEM

A. System overview

The concept "Redivivus" refers to an online portal that brings together all the waste collectors and waste owners who are looking for services. It is simple for users to register with the system and for the waste owners to request for garbage collection and get rewarded with money by the garbage collectors. Also, this application makes it feasible for waste collector to add bin locations where people will put their garbage to be collected. People who are looking for a garbage collectors can search for a garbage collector online and select the best garbage collector based on the reviews or the price. Garbage collector can make the purchase through the system. As a waste collector, you will be able to view the complete purchase history, add a payment method, add recycled second market items. Those are the main functionalities of the system.

B. System overview diagram

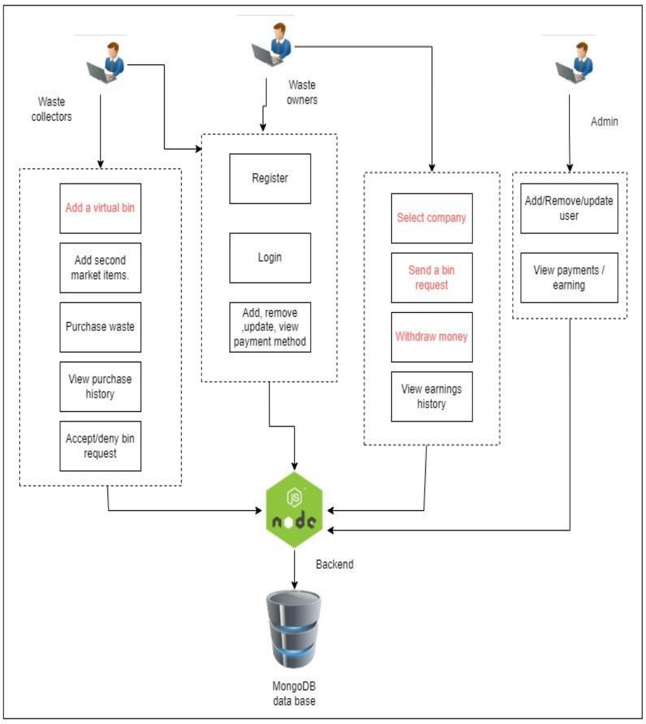

Fig3: System overview diagram

As depicted above waste owners can sell their household recyclable waste to recyclers (company, garbage buyer) of their choice by requesting for a bin location. The web app will be ad free and will be offered free of charge for sellers. Buyers will have to make a payment to their customers (waste owners) through the system where small amount of money will be deducted from their payment after the garbage is collected and amount deducted is for the service our system provides. This will be developed as a responsive web app using MERN stack. This app will help the world achieve the 12th sustainable development goal which is titled 'responsible consumption and production'. Reduction of waste generation is a subgoal which comes under this main development goal.

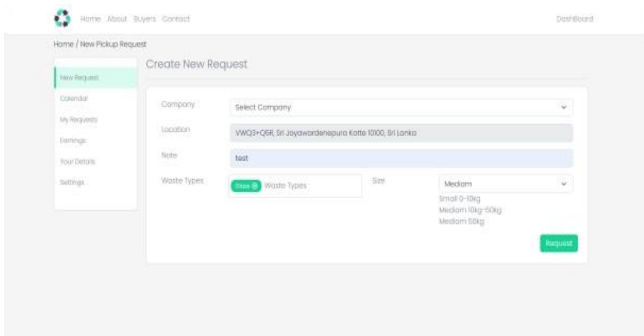

Fig 4: Create a New Bin Request

Using this UI customer can add a new bin location by providing location chosen by Map, and adding the waste types that they are providing and size of the waste(differs from small to medium and large), then customer have to press on send request button.

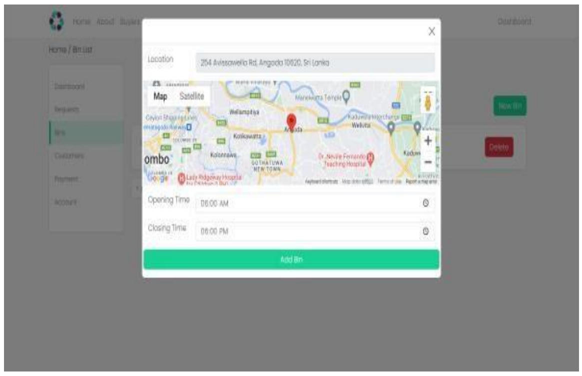

Fig 5: Add Bin Location

After viewing bin request send by customers, companies can choose a location where most customers have requested, and place a bin location, after that companies can set a timer where the bin location will be available, and customers must provide their waste and collect the money.

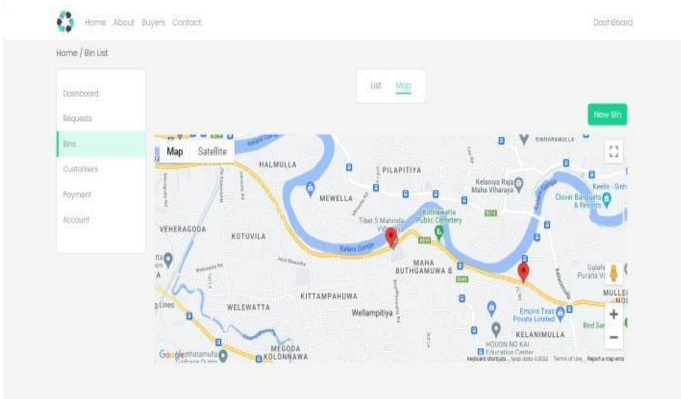

Fig 6: View bin location

Bin locations which were assigned by companies can be viewed in a map or in a list view. Also, after collecting the waste companies can pay the customers who have requested for garbage.

V. DISCUSSION

A. Results of survey

We have conducted a small survey to gather information about the user's opinion about our system, result of that survey is as follows.

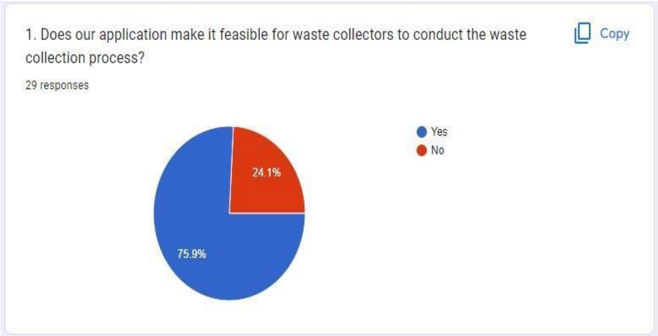

Fig 7: Survey question no.1 result.

According to the above pie chart, we can conclude that 75.9% of the users like this approach of requesting for garbage collection.

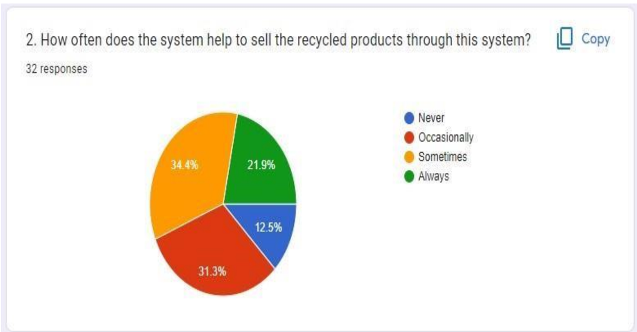

Fig 8: Survey question no.2 result.

Approach we have taken to sell the recycled products as second market products is 34.4 % success according to the above chart, by observing this result we can conclude that, we need to gain trust of the customers who are buying these items.

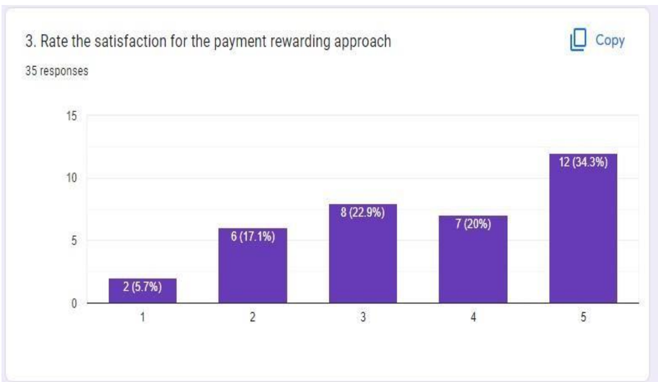

Fig 9: Survey question no.3 result.

Most of the waste owners liked how they are getting paid for what they throw away, therefore our approach is successful. So, waste owner gets more encouraged to sell their garbage to the garbage collectors.

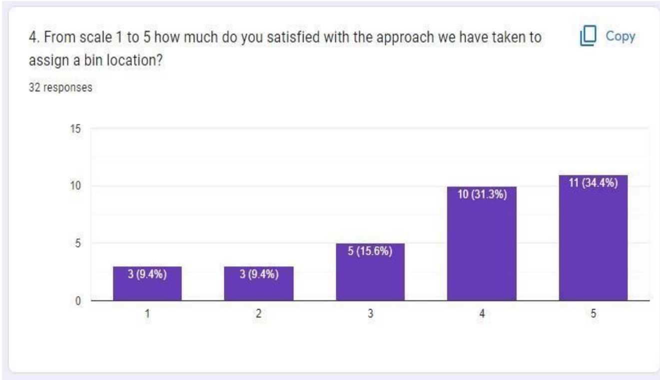

Fig 10: Survey question no.4 result.

As bar chart depicts most of the waste collectors are satisfied with the bin location functionality that we have incorporated in this system.

B. Gaps discussion

Most of the existing system contains IOT technologies incorporated to the bins and contains alerting system which alerts the garbage collectors when the bins are 50% > filled, and some systems have used shortest path algorithms to place the bins where both parties can place and collect garbage in an efficient manner, but in our application we have mainly focused on recycling the waste collected and sell want they have recycled as second market items , also encourage general public to sell their garbage to waste collectors, other than using our web application improving the process of garbage collection more efficient by connecting the waste collectors and waste owners through our application, where waste collectors can request for bin then the waste collector will create a bin where most users have requested, and then the waste owners have to bring their garbage.

Cost wise what we have suggested is less costly due to no IOT technologies are needed, also garbage is sorted according to garbage types when waste owners provide them to bin locations, no cost for different type of bins. Most bins are not required since frequent garbage collection happens due to increased garbage amounts in the areas we have mainly targeted.

Note: Survey was conducted among few numbers of users (aprox 50) .One forum was shared within them.

VI. VI. CONCLUSION

The amount of waste created is continually increasing because of the growing population and greater development. Due to the modern style of life, the nation currently has serious waste management issues. Easy things require more packaging, and people's behaviors—like the inevitable wrappers from fast food—are also tied to producing more garbage. Because more non-degradable materials are present

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in modern garbage, there is a serious waste problem. Garbage dumping, inadequate hospital and hazardous waste treatment, collection, transportation, and disposal, as well as outdated and poor waste management. There are numerous indications that solid waste is a big environmental problem in Sri Lanka. There will be severe detrimental effects on the environment's quality if the current rate of solid waste creation continues without a suitable waste management system. Additionally, the lack of understanding of problems with solid waste management and the consequences of poor SWM have unquestionably made the situation worse.

Sri Lanka requires a long-term objective to create a sustainable and efficient SWM that is economical, profitable, and environmentally sound. The 3Rs, which stand for reduce, reuse, and recycle, are incorporated into the waste management hierarchy and recommended strategies for trash minimization. Several implications could be used to manage the problem in a long-term way. The ideal situation would be to provide education on various scales and standards from elementary schools up to the higher education level. Through formal and informal education, it might be able to alter the attitudes and consciousness of the public. The local government institutions should be given the necessary technical know-how and tools. For those who practice SWM on the field, technical training is a crucial component as well. In addition to technology expertise, WM calls on stakeholder mutual understanding, consultation, and public participation.

Waste segregation is an essential component of SWM, and it is important to teach all stakeholders how to follow its principles. From the smallest households to the highest echelons of government organizations, it should be practiced. A leading independent organization must be created to oversee SWM across the nation. All other institutions that deal with SWM should be under the institution's jurisdiction. The organization might use an effective market model to manage SW profitably. To raise the additional finances needed for the institution's effective management, a legal framework needs also be put in place.

A PPP would also be a great idea to support SWM. By considering the idea of zero waste and alternative WM approaches like waste to energy, sanitary landfills, and speeding composting methodology that are needed to handle the trash in a sustainable manner, the country's current WM policy should be further enhanced. Furthermore, the situation has undoubtedly gotten worse due to a lack of awareness of the issues with solid waste management and the effects of inadequate SWM. Sri Lanka needs a long-term goal to develop an effective and efficient SWM that is cost-effective, profitable, and environmentally responsible. 3Rs, are incorporated into the waste management hierarchy and suggested practices for trash minimization. Several consequences could be applied to permanently manage the issue. The ideal scenario would be to offer encouragement for the people to recycle the waste that they throw away.

REFERENCES

[1] Llic, M. M. and Nikolic, "Waste management benchmarking: A case study of Serbia," *Habitat International,* vol. 460, p. 53:453, 2016.

[2] Mundhe, Jaybhaye and Dorik , "Assessment of Municipal Solid Waste Management of Pune City using Geospatial Tools," *International Journal of Computer Applications (0975 – 8887),* vol. 100, no. 10, pp. 09758887, 2014.

[3] D. Grossmann, J. F. Hudson and D. H. Marks, "Waste generation models for solid waste collection," *Journal of the Environmental Engineering Division,* vol. 100, p. 1219–1230, 1974.

[4] Nilanthi and J. J. Bandara, "Municipal Solid Waste Management –The Sri Lankan Case," *Developments in Forestry and Environment Management in Sri Lanka,* 2008.

[5] K. S. Jeffrey, "Sustainable waste management systems," *November Journal of Cleaner Production,* pp. 16391651, 2010.

[6] S. Zavare, R. Parashare, S. Patil, P. Rathod and P. V. Babanne, "Smart City Waste Management System Using GSM," *Int. J. Comput. Sci. Trends Technol.,* vol. 5, no. 6, p. 74–78, 2017.

[7] T. Singh, R. Mahajan and D. Bagai, "Smart Waste Management using Wireless Sensor Network," *International Journal of Innovative Research in Computer and Communication Engineering,* vol. 4, no. 6, p. 10343–10347, 2016.

[8] S. S. Navghane, K. M. S. and . R. V. M., "“IoT Based Smart Garbage and Waste Collection Bin,”," vol. 5, no. 5, p. 1576–1578.

[9] T. Ambrose, C. Ford and N. Norris, "Smart City Trash Cans," *California Polytechnic State University,* 2015.

[10] “Smart Waste Management solution,” Smart Waste Management System | Waste Analytics | Ecube Labs, 19-Mar-2021. [Online]. Available: http://ecubelabs.com/. [Accessed: 01-Nov-2022].

[11] “The World Leader in Smart Waste & Recycling,” Bigbelly, 20-Oct-2022. [Online]. Available: http://bigbelly.com/. [Accessed: 30-Oct-2022].

[12] “Waste and Recycling Services Right-Sized For You | Enevo,” Enevo Inc. [Online]. Available: http://www.enevo.com/. [Accessed: 30-Oct-2022].

[13] “Smartbin | Smart City | Smart Monitoring | Ultrasonic Level Sensor,” Smart Bin. [Online]. Available: https://www.smartbin.com. [Accessed: 30-Oct-2022].

[14] “Compology | Container Monitoring For Waste,” Compology. [Online]. Available: https://compology.com/. [Accessed: 30-Oct-2022].

[15] “MERN Stack Explained,” MongoDB official documentation. [Online]. Available: https://www.mongodb.com/mern-stack/. [Accessed: 30Oct-2022].