ID 483

Optimum Waste Collection System with Smart Mobile Application

KPMK Leelarathne, RT Niroshan and LP Kalansooriya#

Faculty of Computing, General Sir John Kotelawala Defence University, Ratmalana, Sri Lanka

#pradeepkalansooriya@kdu.ac.lk

Abstract - Irregular disposal and collection of wastage is a huge problem in cities. Due to rapid population growth and manipulation of urbanization, huge garbage emissions and environmental pollution may occur. It is effective and important to manage waste collection to get rid of the issues related to inefficient process of collections, irregular removal of garbage trash bins, overflowing bins and to prevent health issues. Another major challenge for daily life is the current pandemic situation that we have been facing with COVID-19. Therefore, during this pandemic, it is very important to carry out the garbage disposal and collection process in a well-safe and efficient manner at the right time, to minimize contact with outsiders and it will be immensely useful in preventing and controlling the spread of this epidemic. Without proper waste disposal, a home is vulnerable to the spread of disease. This research work plans to develop an optimum waste collection application for truck drivers and citizens. The system will facilitate truck drivers to find the shortest path for the only fullest bin by using route optimization. Arduino and ultrasonic sensors have been used to create the smart bins by facilitating relevant sensor data and Google map API for tracking the location in the proposed application. Mainly Firebase for backend resources to the device, including data storage, user authentication, static hosting has been used, while Flutter has been used as the mobile application development platform. As per the studies and analysis of the related technologies and platforms, the Flutter is used to develop cross-platform applications for Android, iOS, Linux, Mac, Windows operating systems. The proposed work provides an accurate, convenient, user-friendly Android mobile application as the final research output.

Keywords: route optimization, urbanization, firebase, Google map API

I. INTRODUCTION

Manage waste collection services play a major role in the efficient use of public services with the rapid population growth and the manipulation of urbanization. Especially, due to the current pandemic of Covid 19, it is important to have a proper and well-managed garbage disposal and waste collection process to ensure the safety and good health of everyday life. Then the proper management and planning for wastage collection is a priority key factor for “Smart City”. Waste management is a central feature of every society. (Singh & R.Saxena, 2018) (M.S.Kadam & S.S.Sarawade, 2016) It has evolved along with societal development and growth.. Nowadays smart waste processes have an important role in evolving waste management. Internet of things (IoT) technology and emerging modern computing platforms offer new opportunities to automate waste management. (Amir & Rola Pola Anto, 2018). Existing waste dumping sites are full beyond capacity and under unsanitary conditions. The prominently Environmental pollution may be owing to the Municipal Solid trashes. (Augustyn, et al., 2019) (McAllister, 2015) The world generates 2.01 billion tonnes of municipal solid waste annually, with at least 33 percent of that extremely conservatively; not managed in an environmentally safe manner. Worldwide, waste generated per person per day averages 0.74 kilograms but ranges widely, from 0.11 to 4.54 kilograms. It is perceived that usually the waste space gains too much assigned due to irregular removal of garbage occupancy in the dustbin. The aim of this work is to use the modern computing domain to enhance the quality, performance, and interactivity of urban services, and hence provide an efficient and proper waste management system that will overcome the shortcomings of the present waste collection procedure additionally decrease cost and create better utilization of resources. Here it is presented a cloud-based system that will find the best route for collecting waste. This smart and expert system can take dynamic decisions and control special situations such as a collection

route is blocked, waste level and the number of required trucks exceed capacity, etc. Most developed countries passed through a period when they were developing environmentally. Today, however, most of these countries have effectively addressed much of the health and environmental pollution issues associated with wastes generation. The total solid waste generated in Sri Lanka (Reinhart, 2020) is assumed to be around 6,400 tons/day but daily waste collection by Local Authorities is estimated at 3500 tons.

Western Province	58.5%
Eastern Province	8.5%
Central Province	8%
Southern Province	7%
NW Province	6%
Northern Province	3.3%
Sabaragamuwa Province	3.2%
Uva Province	3%
NC Province	2.5%

Figure 1. Percentage of Solid Waste collected by Local Authorities Sri Lanka

As a result, there is a serious threat to the excessive accumulation of solid waste in the urban environment. Owing to the urban-rural divide, a similar scenario is now occurring in rural areas as well. Today, coping with waste is a big challenge. Furthermore, when it has done the research and gathered information about the current waste collection procedure in Sri Lanka and as well as global resources regarding the waste collection process it can be concluded as follows.

- In Sri Lanka it has usually 5 days waste collection procedure
- Only the well-Developed countries used fully automated method for waste collection
- Truck drivers are still unable to drive through narrow streets and rural villages.
- Throwing garbage to the roads
- Health issues. (ex: Dengue, Kolara)
- Traditional waste management (TWM) procedure wasting cost & fuel

II. LITERATURE REVIEW

Waste management and waste collection can be defined as one of the popular research problems that have been developing with various conceptual modern computing and engineering techniques and IoT-based models. The following studies were conducted on the waste management and waste collection procedural studying areas of the different main categories of existing waste collection process with various applications and the techniques in globally and as well as Sri Lankan context. Authorities describe the Waste Management activities. Each stakeholder seems to have their own responsibilities. The municipality must take very good care that waste can be recycled, and households must be careful to separate recyclable materials from household waste. Metropolitan strong waste, normally known as trash or waste, is non unsafe disposed of materials created by family units, organizations, plants, cultivating, and sewage. This is comprised of waste, organics, and recyclable materials, and its administration is constrained by the region. Civil strong waste is normally gathered, exasperated, and sent for handling to either a Landfill or Municipal Recycling Centre. (Busch, 2016).

EU Waste System Directive sets down waste necessities Maintenance and reusing. Part States must actualize squander the board arrangements in consistence with the rule, where the reusing objective for all waste materials from families is half. Indeed, this implies that by 2020 Finland should reuse 50% of its metropolitan waste. The order presents the 'polluter pays rule' and the 'broadened duty of makers.' It consolidates arrangements on dangerous waste constantly oils (old Directives on unsafe waste a lot of oils annulled with impact from 12 December 2010) and incorporates two new reusing and recuperation focuses to be accomplished by 2020: half groundwork for the reuse and reusing of certain waste materials from families and other comparable sources; and 70% planning of waste materials from families. Part States are needed by the Directive to execute squander the executive's plans and waste decrease programs.

Figure 2. Waste Management hierarchy

Source:https://ec.europa.eu/environment/waste/framework/

The Trash assortment and control was a major worry that should be examined. In "'Review of: Smart Bins for Garbage Monitoring and Collection Using IoT System by the Prof. S. P. Pander speaks to the proposed Garbage assortment and the board framework for private or business territories utilizing the Internet of Things. In this paper, (Pande, 2019) brilliant canister is based on Arduino 328board, a microcontroller-based stage that interfaces with GSM modem and Ultrasonic sensor. This program tracks the trash canisters and informs by means of a page concerning the measure of trash gathered in the trash receptacles. This page additionally sends the trash assortment vehicles with all the information. This IoT Garbage checking framework venture is a creative framework that will help keep the towns clean.

G. Arunkumar and G. Bhanu Priya, have done research work on "SMART GARBAGE COLLECTING BIN FOR MUNICIPAL SOLID WASTE." for the International Journal of Modern Trends in Engineering and Science. And the authors had researched for minimization of end-to-end delay in the implementation of smart waste management. The automatic waste management system is the latest trend in this research work and is one of the best combinations to use in this (Arunkumar & G. Bhanu Priya, 2016).

O. Osibanjo and I. C. Nnorom presented an E article and proposed a Smart City waste management system (SWM) that allowed for IoT applications. Originally, the Smart Waste Management (SWM) program was developed in smart cities. E SWM system provides on-time garbage collection that ultimately minimizes the total cost of the garbage collection process. e proposed work shows that the IoT waste management system empowers cleaning operators to detect cleaning problems in real-time. This system thus helps to improve overall productivity and cleanliness. (Osibanjo & I. C. Nnorom,, 2007)

Internet of things (IoT) is an emerging technology that offers promising solutions for the modernization of traditional systems. It makes successful agreements resulting in the crystallization of smart cities, smart houses, smart manufacturing, and the smart world. This article has introduced a smart waste management architecture for smart cities and an effective routing strategy with the least architectural delay considered.

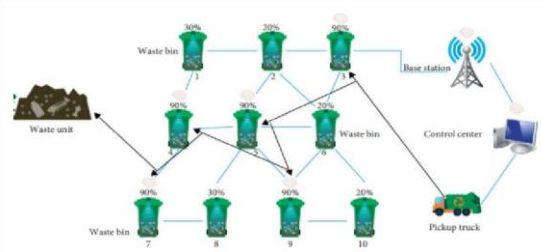

Figure 3. IoT-Enabled Smart Waste Bin Management System and Efficient Route Selection

C. Chow, W.-M. W. So, and T.-Y. Cheung has worked on another new waste collection bin to help facilitate education in plastic recycling. Aside from landfills and incineration, plastic recycling has been an alternative method for solid waste management. Recycling quality is, however, affected when all plastics are discarded into a single recycling bin which increases the recycling industry's cross-contamination and operational costs. With the following the design process of the engineering, a new eight-compartment plastic waste collection bin is designed to facilitate plastic recycling and source sorting, which also provides educators with insight into solving environmental problems. The quantities of collected plastic waste correspond well to the dimensions of the building (Chow & W.-M. W. So, 2018) ICT and PC organizing have arrived at pretty much every part of present-day life and affect human existence even in the most far off territories of agricultural nations. (Wilson & C. Velis, 2006) (Usón & G. Ferreira, 2013). The fast development in ICT has prompted an expansion in PC ability and yet to a decline in the lifetime of the products because of which developing amounts of waste electrical and electronic hardware (e-squander) are created every year. For most agricultural nations, particularly in Africa, the creation of ICTs relies more upon second-hand or renovated EEEs, the

vast majority of which are imported without corroborative usefulness testing. A. K. Jha, S. K. Singh, G. P. Singh, and P. K. Gupta, have suggested ideas in this research way (Jha & S. K. Singh, 2011), critical volumes of e-squander are being treated in these nations. The difficulties confronting agricultural nations in e-squander the board include: the absence of sufficient waste administration frameworks, the absence of enactment explicitly managing e-squander, the nonattendance of any End-of-Life (EoL) item reclaim framework, or the presentation of expanded maker obligation.

When it has moved to related works and researched based on the position of waste management within Sri Lankan context-based (Foundation, 2017)the research works and facts in Status of Waste Management in Sri Lanka," Environment Foundation (Guarantee) Limited; given the ongoing catastrophe at Meethotamulla and the misguided choice to dump trash in Muthurajawela, an asylum of wetlands under the Fauna and Flora Ordinance, it is valuable to discover the set of experiences to squander the board in Sri Lanka. With the Western Province representing roughly 60% of waste creation, Sri Lanka produces 7000 MT of strong waste each day. Everybody produces a normal of 10.4 kg of waste a day. Just 50% of the waste produced is gathered, as per the Waste Management Authority, and the Central Environmental Authority. Appraisal of the existence cycle, arrangement, reusing, and decrease of every single waste sort, and appropriate landfilling is necessary.

Duties regarding gathering and discarding waste are assigned to the nearby specialists of the particular Divisional Secretariat, either a metropolitan chamber (according to Municipal Council Ordinance - 1947), a metropolitan board (Urban Councils Ordinance-1939), or a locale committee (Pradeshiya Sabha Act – 1987). Squander the board and removal arrangements are made as per the 1981 National Environmental Act No.47 and Public Nuisance Ordinance. Government organizations have been attempting to sort out the nation's best waste administration methodology throughout the previous 20 years, or somewhere in the vicinity. Albeit a few strategies and activities advanced clean landfills, different measures were directed into energy programs against squandering. CEA started a 10-year squander the executives' framework called the "Pilisaru Project" in 2008 with the objective of "Squander Free Sri Lanka by 2018." Unfortunately, the absence of a cognizant durable methodology has added to unintelligible and fruitless procedures.

This examines the overall highlights of casual reusing, featuring both positive and negative perspectives experience shows that the foundation of new conventional waste reusing frameworks without considering previously existing casual frameworks can be profoundly counterproductive. The best option is to consolidate the casual area into squander the executives arranging, drawing on their conventions and skill and simultaneously trying to improve the manageability and living and working states of those concerned. The preferred option is to integrate the informal sector into waste management planning, building on their practices and experience, while working to improve efficiency and the living and working conditions of those involved. Issues associated with integrating informal recycling into the formal waste management sector are discussed in this research works respectively. (Pariatamb & Masaru Tanaka, 2017) (Basnayake & Chettiyappan Visvanathan, 2014)

Plastic, polythene, metal, and glass reusing endeavours should be energized and financed at various scales, and the distance between squander makers and recyclers should be topped by setting off more assortment communities and making the cycle more freely available. As discussed, and worked on his research by (Cialani & R. Mortazavi, 2020). Squander is an asset and effective activities in the waste business should be made, and it should be set up as an organization that produces pay instead of an industry of no incentive for the company.

Specialists need to utilize logical specialists to decide the best waste administration model in Sri Lanka, regardless of whether it be waste-to-energy, cremation, or a mix of the two. Landfills at present should be thought of, as there will be an amount of expendable waste delivered even after burning and from other waste to energy tasks. In the event that such waste fizzles for brief energy activities, the landfill would need to be held as a choice. As a common society, we have an obligation to urge individuals to move towards more feasible and asset productive types of use. (Dahlén & A. Lagerkvist, n.d.)

Table 1. Different Ranges of Daily MSW Collection[tones/day]

	Number of Local Authorities
Up to 1	111
1-2	48
2-5	76
5-10	26
10-20	23
20-50	19
50-100	5
100-150	2
>150	1
Total Number of Local Authorities	111

Table 2. National Color Codes for Waste Separation Containers

Color	**Description**
Green	Organic Waste
Blue	Paper wastes
Red	Glass, Bottles
Brown	Metals, Coconut Shells
Orange	Plastics/Polythene

III. METHODOLOGY

Smart waste management and optimization are some of the upcoming topics in today's research works. Out of all optimization and waste collection systems and procedures slightly challenging this research area in the general public and urban council authorities because, even though the same citizen or same city, it has to manage several varieties of trash and garbage and it may have different garbage disposal routines or habits. Not only that but also day by day the amount of waste disposal may increase with the high population growth and industrialization.

After selecting a topic for the research, initial information about related works for this research that have collected already were gathered by the literature review as well as have done interviews with the urban council authorities and as well as the randomly selected citizens in the general public who are involved with this waste management and waste disposal domain. Since there aren't the same research works that have been done, related proposed systems in waste collection and apparel market analysis studies research have been reviewed. When reading various journal papers and conference papers there were so many approaches and techniques that have been developed to enhance the efficiency and design IoT based systematic approaches. The analysis was done mainly to identify the current systems available with the advantages and drawbacks of such systems and get the ideas & preferences of individuals within the society is related to waste collection procedures.

- Data gathering and collect from the smart bins.
- Fill level of bin-ultrasonic sensor
- And then it sends data to the cloud using GSM module
- Shortest path-shortest path algorithm
- Nearest bin & bin locations-Google map API platform

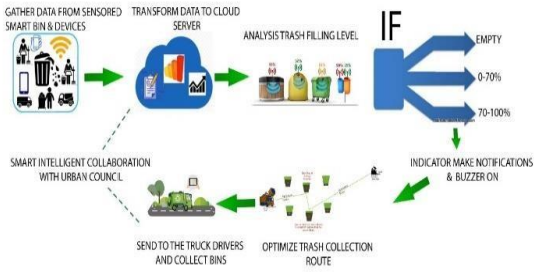

Figure 4. Methodology of the overall solution

Citizens can put waste in the smart bin. Then smart bin measures fill level using an ultrasonic sensor. Those details send to the AWS through the GSM module. Then AWS sends that relevant data to the database. According to that detail's citizen map is working. Then it viewed the Filled bin-red color and unfilled bin-green color. Furthermore, if filled between 70%-100% showed in red color and otherwise shown in green color in the app. After logging into the app citizen can find the nearest bin and truck driver's location. And the app has separate logging for the truck driver, and the truck driver can be logged into using the phone number and relevant OTP,

and then it shows the next nearest bin, and then the truck driver can collect the nearest filled bin. In addition to that main process, citizens are capable of add complaints using app and it sends to the database.

IV. PROPOSED SOLUTION

In order to obtain an optimum waste collection system to fulfill the efficiency and optimization this research work will propose an application that In this proposed system there are multiple dustbins located through the exact locations in the particular city, these dustbins are provided with low-cost sensor that helps in tracking the level of the trash bins and a unique ID will be provided for every dustbin in the city so that it is easy to identify which garbage bin is fill. When the amount reaches the edge limit, the device will transmit the amount by the unique ID provided. This information can be accessed by the concern authorities from their place with the help of internet and instant action can be made to clean the dustbins. The main objective of our project enables a two-way communication between the infrastructures deployed within the city and the operators/administrators. A centralized system for real-time monitoring is our goal to fulfil. During this method both the municipal and citizens have the benefit from an optimized system which results in major cost savings and fewer urban pollution. The final proposed solution can be summarized as illustrated in Figure 5.

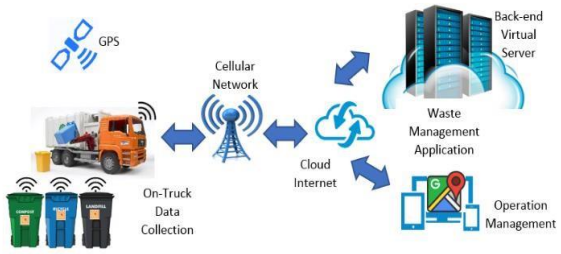

Figure 5. Smart Waste Management System Schematic of Proposed Solutin

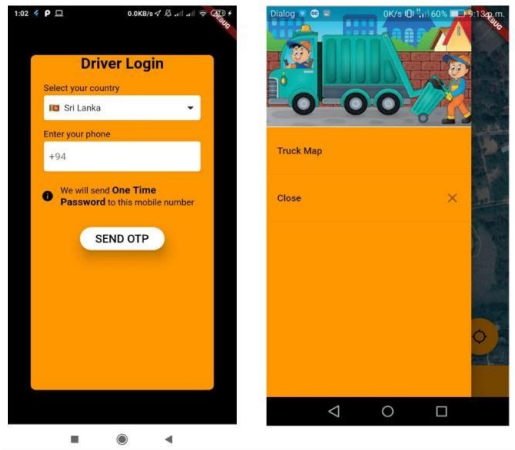

Figure 6. Driver Login Page User Interfaces

This system also has a mobile application. It supports both citizens and truck drivers. A citizen can find the nearest bin and truck driver locations. A truck driver can find the nearest next filled bin and collect it. Because of this app, the truck driver can skip the unfilled bin. Driver login there is a drawer to enter for the truck driver login page and it sends an OTP for verification while the Drive login. Any unauthorized person may not be allowed to log through the driver login except the authorized truck drivers. And then after successful login, it can be viewed the bin locations in one interface and then in another interface, it can be viewed the nearest filled bins with the citizen's locations before starting the collection process. On the screen, it shows the unfilled bins in green colour icons and can be easily identified the filled bins in red colour icons. Then the driver can load the map and by clicking the Start Ride button the driver is allowed to start the ride to fulfill the waste collection process. Then according to this map with the corresponding filled bins, the drivers may lead to an efficient waste collection process. And then the citizens also can experience the smart waste collection procedure with this proposed solution. The User interfaces of this explained process can be represented as in Figure 6.

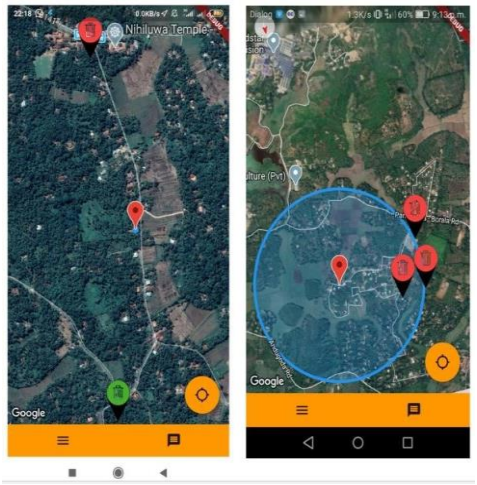

Figure 7. Bin Locations and Map View User Interfaces

V. DESIGN & IMPLEMENTATION

Under the design, mainly it must do the selecting the appropriate tools and platform in order to build up the software design architecture for the mobile app implementation. Design and Development will explain how the technological strategies and tools were decided to create this application and the process that has followed to construct the proposed system. This system implementation and design mainly consist of two phases. They are gathering and sending data from the waste bins and finding the optimal route for the waste collection process.

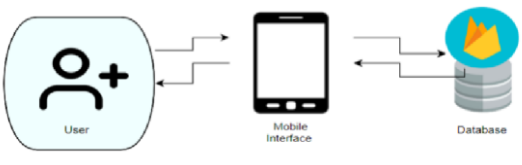

Figure 8. High-level System Design Architecture of the Application

The first phase mainly focuses on collecting data from waste bins using sensors and sending them to the server. Both the weight and filling level of trash bins is sensed using two sensors that are fixed with the trash bin to gather data. To detect the filling level ultrasonic sensors are used. It operates with the propagation of sound waves. Distance to object is determined via a sound transit time. And it is not detected by color, transparency, or glossiness of a surface which is very much advantageous for sensing waste filling level. Other than that, the LED display shows if the container is full to alert the users. All these data gathered are sent for the processing which is done using a Microcontroller and GPRS (General Packet Radio Service). The data collected from sensors requires filtering and sorting. These raw data will be formatted into structured data. A central server receives the data and stores all the necessary information for current and future use.

Then the second main phase is Finding Optimal Route for Waste Collection. In this stage, we find the optimal route for waste collection. If the truck can collect all the waste from any place with the shortest possible path, it can save fuel, money, and time. Moreover, we analyze the usage pattern of different localities to collect maximum waste and allow waste bins more time to fill up. In this phase, I use the Google Maps API platform to find the nearest bin. A truck driver can easily find the nearest filled bin skip the nearest unfilled bins. According to the app, it shows unfilled bin in green color and filled bin in red color. This system must be a mobile-based framework for the problem domain. There are several languages to produce mobile devices, as well as platforms. As the project objectives and the system architecture of the outcome initially have studied the latest appropriate technological domains and then finalized to use in the application implementation as below.

A. Flutter

Flutter is very innovative but perhaps a promising platform that had already attracted the attention of big companies that have already released their apps. Since components are implemented in Flutter itself, however, there is no layer of communication between the view and the code. So, buttons, text, media elements, and context are all drawn by the graphics engine of Flutter. Widgets are essential elements of the user interface used to construct the application's user interface and build stunning, highly customized user interfaces.

B. Ardiuno

Arduino is an open-source electronic prototyping platform focused on easy-to-use software and hardware. Arduino is a prototyping board based on a microcontroller that can be used in the development of digital devices that can read inputs such as a finger on a button, touch a screen, light a sensor, etc. and convert it into output such as flipping on an LED, turning a

motor, playing songs via a speaker, etc. Arduino board consists of a USB plug for communicating with your machine and a bunch of link sockets that can be connected to external devices such as motors, LEDs, etc. There are many factors that made this possible, such as rapid growth in information technology, lower electronic product, and device costs and widespread internet connectivity.

C. Ultrasonic Sensor

The Ultrasonic Sensor (Distance-adjustable or Zone-setting Convergent Reflective Sensor) sends ultrasonic waves from an emitter to a sensing target, and then receives a detector for the reflected waves. The Sensor uses the resulting information to assess an object's location, or to measure the object's distance. This Sensor Form decides the Distance from the Sensor to an object based on the time taken from the transmission of the ultrasonic waves before they are received with the sound intensity. Unlike photoelectric sensors, Ultrasonic Sensors can detect an object without having its colors affected it.

D. Firebase

Firebase is a powerful platform for your Web and Mobile App. Firebase will supply backend resources to your device, including data storage, user authentication, static hosting, and more. You can easily create mobile and web apps with Firebase that scale from one user to a million. What noteworthy is that people were using Envolve to transfer data on applications that were more than just talking messages. Developers were using Envolve to synchronize real-time application data such as a game state through their users.

E. Google Map API

Google Maps is an application and technology provided by Google for the web-based mapping service. The Google Maps API gives you the ability to create personalized maps that can be used to create modern applications based on Google Maps. The maps are loaded using an API key in all Maps API applications. The API key is free, but Google will track the use of the Maps API for your application and, if it reaches the use cap, it will need to buy an additional quota. With those, all the above technologies adopted have described the various tools that were used along with the programming languages, platforms, frameworks, and development environments throughout the design and implementation process. In addition, this explored how those technologies committed themselves to growth and the uniqueness of the application.

VI. FINDINGS & ANALYSIS

This explains how the data were gathered to create this program and the process of the table below shows the main findings and existing problems found while analyzing and data gathering process, and the solutions offered by the newly implemented Optimum Waste Collection system to resolve those problems. The data were gathered from previous works and the interviews conducted with truck drivers in the municipal council and citizens in selected areas for this proposed project. Mainly it has been concerned to find the existing procedures of waste collection systems and the drawbacks or problems encountered in the waste management process in the Sri Lankan context. A survey on the regular waste collection process and citizens' perspectives in the general public was held as the initial finding of this research problem moreover and to measure the factors which may affect the existing waste collection process and the drawbacks of the current methods. This Google form questionnaire-based survey was collected 65 responses. It consisted of 10 different question tips regarding traditional waste management procedures, environmental pollution level, issues that occurred on citizens' side as well as the problems faced by truck drivers and trash bin collectors to identify for the respondents. As well as the main summary of this questionnaire has concerned two major analyses under separate questions to determine what the satisfaction or overall acceptance of the citizens and garbage collectors during the existing waste collection process is. And to determine and analyze the most prominent and prioritized issues to be addressed via this research work and proposed solution. According to responses, respondents were related to several areas in the country, both urban areas & rural villages, every category of age group. When considering about total average of existing situation and issues facing with the traditional waste collection system by the general public generally it could conclude as below. With 63.3% of the percentage as the highest scored citizens who are not satisfied with the current waste collection procedures in particular areas, only 10% of respondents are in totally satisfied with

current waste collection procedures in their areas.

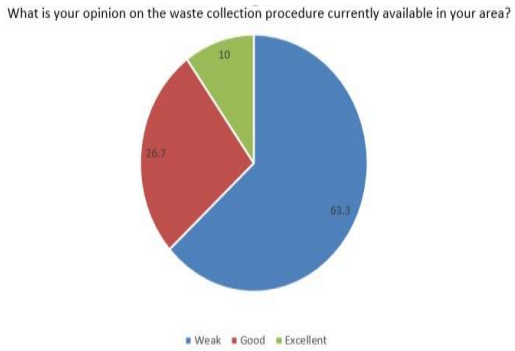

Figure 9. Pie chart I of Questionnaire Survey Results

And we have analyzed that environmental pollution can be defined as another major adverse effect of improper waste collection. So, then it may occur health diseases and can be threatening to the day-to-day healthy life of the citizens. So, this finding with the responses has clearly represented how those problems affect the general public, and then it is required to pay attention in order to address these existing problems with the traditional waste management process. The highest score with 66.4% have agreed about this issue and they are expecting a proper solution for this at least some considerable extent.

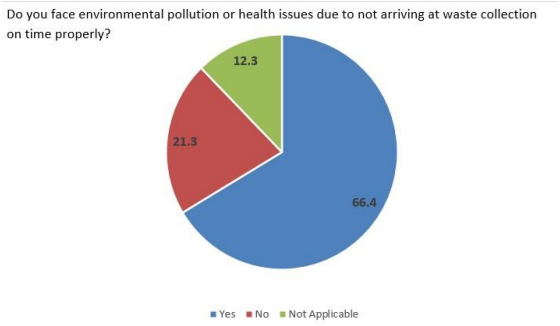

Figure 10. Pie chart II of Questionnaire Survey Results

Finally, out of all those survey results and analyses, it is concluded to determine and address the current burning issues in the waste collection system and propose a smart optimum solution as the final system. The below table reflects the main findings and existing problems found while analyzing and data gathering process, and the solutions offered by the newly implemented Smart Waste Collection system to resolve those problems specifically.

Table 3. Overall Analysis of the proposed Solution

Findings/ Problem Encountered	**Analysed Solution**
Traditional waste management (TWM)procedure wasting cost & fuel	Collect only filled bins, no need to go for unfilled bins
Health Issues	Stop Bins overflowing
Increased level of environment pollution	Control the bin overflowing and collect waste timely
Time wasting (Traffic Jam)	Manage bin collecting routes
Improper & inefficient collection	Collect only the filled bins which have reached the filling level

VII. CONCLUSION AND FUTURE WORKS

The present status of the solid waste management practices in Sri Lanka is required to concern with more on time and well managed regular collection process. One of the difficult operational problems that municipal and local authorities are facing is the collection of municipal solid waste. In recent years, the exponential population growth, high density of urban areas, diverse culture, changing food habits, and lifestyles have seen an unresolved problem in terms of Municipal Solid Waste Management. Consequently, the municipalities have been facing many other issues related to the collection, management of solid waste. The present study is a comprehensive review of research work on the present waste management status identifying the associated challenges and deriving potential solutions for the optimum waste collection application in the Sri Lankan context. The proposed work demonstrates that the waste management system in the Mobile application empowers the collection operators to detect waste bin filling level issues in real-time. We have used smart bins in which waste-detecting sensors are fixed. These sensors can send signals to the nearest sensor referenced to the base urban council. Therefore, this system helps in increasing overall productivity and efficiency. The proposed system contains all the important stages from the collection of waste in

the filled bins, load to the truck and using the optimum shortest route for transportation and does the collection process will not occur any traffic jam, unnecessary delay. and recycling it in the recycling unit. As future works main aspect of this proposed work can be defined as recycling of the waste and proper storage and maintenance in the storage units too. To create a highly accurate and efficient Smart Waste Collection System with the Mobile App development this paper has been reviewed the existing technologies and related works done within other several related research areas. Even though there are so many various waste management and waste collection systematic approaches and as well as waste management and related research have been done already, there isn't an existing system with a mobile application to address these current issues have been facing in the Waste Collection process on overall Traditional Waste Collection strategy, especially in Sri Lanka. As a further enhancement, the Google map API advanced feature activation can be added with more efficient use of the app and enhance the additional important hardware parts for future development. To gain a conclusion on such a research study area the information on the effectiveness of a systematic solution may have been gathered by reviewing related works and existing systems and then its evaluation summary gave the points to be considered in developing such a real-world application in future with the digital era and to survive with the future challenges such as pandemic situations and current new normal.

REFERENCES

Amir, M. & Rola Pola Anto, 2018. A Study Policy Implementation of Waste Management in Konawe Regency-Indonesia. Journal of Sustainable Development, Volume Vol. 11, No. 1.

Arunkumar, G. & G. Bhanu Priya, 2016. SMART

GARBAGE COLLECTING BIN FOR MUNICIPAL SOLID WASTE. International Journal of Modern Trends in Engineering and Science.

Augustyn, A., Alicja Zelazko & J. P. R., 2019. Britannica. [Online]

Available at:

https://www.britannica.com/technology/waste-disposalsystem

Basnayake, B. F. A. & Chettiyappan Visvanathan, 2014. Solid Waste Management in Sri Lanka. Municipal Waste Management in Asia and the Pasific Islands, pp. 299-316.

Busch, C., 2016. BUSCH Systems. [Online]

Available at: https://www.buschsystems.com/resourcecenter/knowledgeBase/glossary/what-is-municipal-solidwaste-msw

Chow, C. & W.-M. W. So, T.-Y. C., 2018. Research and development of a new waste collection bin to facilitate education in plastic recycling. Sustainability - Trends in Municipal Solid Waste Management.

Cialani, C. & R. Mortazavi, 2020. The Cost of Urban Waste Management. Frontiers in Sustainable Cities.

Dahlén, L. & A. Lagerkvist, n.d. Evaluation of recycling programmes in household waste collection systems. Journal of Waste Management, Volume 28, pp. 100-1112.

Foundation, E., 2017. Status of Waste Management in Sri Lanka. [Online]

Available at: https://efl.lk/status-waste-management-srilanka/

Jha, A. K. & S. K. Singh, 2011. Sustainable municipal solid waste management in low income group of cities. International Society for Tropical Ecology, pp. 123-131.

M.S.Kadam & S.S.Sarawade, 2016. Study and Analysis of Solid Waste Management Challenges and. IOSR Journal of Mechanical & Civil Engineering (IOSRJMCE), Issue eISSN: 2278-1684,p-ISSN: 2320-334X, p. 8.

McAllister, J., 2015. FACTORS INFLUENCING SOLID-WASTE MANAGEMENT IN THE DEVELOPING WORLD, Logan, Utah: Utah State University.

Osibanjo, O. & I. C. Nnorom,, 2007. The challenge of electronic waste (e-waste) management in developing countries. The Journal for a Sustainable Circular Economy, 25(6), pp. 489-501.

Pande, P. S. P., 2019. Smart Bins for Garbage Monitoring and Collection Using IoT System. International Journal of Research and Scientific Innovation (IJRSI).

Pariatamb, A. & Masaru Tanaka, 2017. Municipal Solid

Waste Management in Asia and the Pacific Islands: Challenges and Strategic Solutions.

Reinhart, C., 2020. The World Bank. [Online] Available at: https://datatopics.worldbank.org/what-awaste/trends_in_solid_waste_management.html [Accessed 2021].

Singh, J. & R.Saxena, 2018. The Important of Waste Management to Environmental Sanitation.

Usón, A. A. & G. Ferreira, 2013. Environmental-benefit analysis of two urban waste collection systems. Science of the Total Environment, pp. 72-77.

Wilson, D. C. & C. Velis, 2006. Role of informal sector recycling in waste management in developing countries. Open Journal of Civil Engineering, Volume 30, p. 797–808.

ACKNOWLEDGMENT

Authors would like to express their great appreciation and the gratitude to those who have supported this research work