DEVELOPMENT OF ONLINE SCHEDULED WASTE COLLECTION SYSTEM FROM HOUSEHOLDS

AZREE AZHAR BIN AWI

FACULTY OF ENGINEERING

UNIVERSITY OF MALAYA

KUALA LUMPUR

2022

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AZREE AZHAR BIN AWI

RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ENGINEERING (SAFETY, HEALTH AND ENVIRONMENT)

FACULTY OF ENGINEERING
UNIVERSITY OF MALAYA
KUALA LUMPUR

2022

UNIVERSITY OF MALAYA

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DEVELOPMENT OF ONLINE SCHEDULED WASTE COLLECTION SYSTEM FROM HOUSEHOLDS

ABSTRACT

In 2020, more than 70,000 tonnes of scheduled waste were generated from Malaysian households. From this, used cooking oil make up almost 85%, while more than 10% are electronic wastes and the rest are used paint, pesticides, solvents, used lubricants and others. Nowadays, most household cooking oil are stored in plastic bottles or containers, although it was found that used cooking oil was also disposed into kitchen sinks as traces of the oil have been found in municipal drainage systems. Used cooking oil that flow into the kitchen sink and enter plumbing systems would eventually clog the wastewater outflow due to prolonged sedimentation. After which, plumbing systems become dirty and smelly inside. As for other scheduled household waste, it is common that they are stored in garbage bags mixed with other solid waste such as food waste and plastic film, before being disposed. The mixed solid waste is then collected by municipal dump-trucks to be transported to municipal landfills. Later, it becomes a problem for landfill operators to segregate the scheduled waste from the solid wastes. Currently, only industrial and companies' scheduled waste are compulsory to be reported and collected through a web system called the ESWIS while no systems are available for households to report and collect their scheduled waste. To meet the paper objectives, a series of hypothesis validation method has been done with selected households within the target area. Issues and major problems have been identified while conducting the validation study. Based on the analysis, 93% of households validate the use of the online scheduled waste collection system because it is more user-friendly and easier to use than existing methods. At least 80% of homes have sent their scheduled waste to recycling centres, indicating that the majority of families are aware of the importance of waste recycling. However, the majority of households were unaware of the scheduled waste collection service, and at least 73% of them believe that engaging the current booking service is difficult owing to unclear procedures and insufficient communication. The implementation of the online system will save 3500 tonnes of scheduled waste from households every year from being dump to the environment. .

PEMBANGUNAN SISTEM KUTIPAN BAHAN BUANGAN TERJADUAL MELALUI PLATFORM ATAS TALIAN UNTUK ISI RUMAH

ABSTRAK

Lebih 70,000 tan bahan buangan terjadual dihasilkan daripada isi-rumah di Malaysia pada tahun 2020. Daripada nilai ini, hampir 85% telah disumbangkan oleh minyak masak terpakai, lebih 10% daripada bahan buangan elektronik dan selebihnya adalah daripada sisa cat, racun serangga, sisa kimia, pelincir terpakai dan lain-lain. Pada hari ini, kebanyakan minyak masak terpakai dalam isi-rumah disimpan dalam botol atau bekas plastik, walaupun dipercayai minyak ini juga telah dibuang ke dalam sinki rumah kerana dijumpai kesan minyak masak terpakai di dalam sistem longkang kumbahan. Minyak masak terpakai yang telah dibuang ke dalam sinki dapur, kemudiannya akan melalui sistem perpaipan rumah dan menyebabkan air kotor tersekat disebabkan penambakan yang berlarutan. Selepas sekian masa, sistem kumbahan rumah akan menjadi kotor dan busuk. Manakala untuk bahan buangan terjadual lain, biasanya ia akan dibuang bersama sisa pepejal lain seperti sisa makanan dan bekas plastik, sebelum diangkut. Bahan buangan campuran ini kemudiannya akan diangkut oleh lori sampah untuk dihantar ke tapak pelupusan sampah. Ini kemudian menjadi masalah kepada operasi tapak pelupusan untuk mengasingkan bahan buangan terjadual dan juga sisa pepejal biasa. Pada hari ini, hanya syarikat dan kilang sahaja yang mempunyai bahan buangan terjadual wajib untuk melaporkan dan dikumpul melalui sistem maya yang dipanggil ESWIS. Manakala isi-rumah masih tidak mempunyai apa-apa sistem yang boleh digunakan. Bagi memenuhi objektif kajian, satu siri kaedah pengesahan hipotesis telah dilakukan dengan isi-rumah terpilih dalam kawasan sasaran. Isu dan masalah utama telah dikenalpasti semasa menjalankan kajian pengesahan. Berdasarkan analisis, 93% isi rumah mengesahkan penggunaan sistem kutipan sisa berjadual dalam talian kerana ia lebih mesra pengguna dan mudah digunakan berbanding kaedah sedia ada. Sekurang-kurangnya 80% isi-rumah telah menghantar sisa terjadual mereka ke pusat kitar semula, menunjukkan bahawa majoriti keluarga menyedari kepentingan kitar semula sisa terjadual. Walau bagaimanapun, majoriti isi-rumah tidak mengetahui perkhidmatan kutipan sisa terjadual terus dari rumah, dan sekurang-kurangnya 73% daripada mereka percaya bahawa menggunakan perkhidmatan tempahan ini adalah sukar kerana prosedur yang tidak jelas dan komunikasi yang

tidak mencukupi. Penggunaan sistem ini dijangka menyelamatkan 3500 tan sisa terjadual setiap tahun daripada dibuang ke alam sekitar.

ACKNOWLEDGEMENTS

I would like to take this opportunity to express my sincere gratitude and thanks to Professor Ir. Dr. Abdul Aziz Bin Abdul Raman and his associate, Dr. Archina Buthiyappan for their dedicated supervision, warm advice and constructive comments. The completion of this research paper could not have been possible without their guidance. Special thanks to all HSE department person-in-charge from Fathopes Energy, Amita Berjaya and Jaring Metal Industry whom had spared their valuable time, discussing their experience in waste disposal, scheduled waste management and logistic collection operation. Their invaluable inputs and knowledge in the industry have been very instrumental throughout the study. Thanks to my classmates as well, who have been always in front foot with the updates of the research project. Their commitments have always been motivating me from the day one. Last but not least, I would like to thank my beloved family who has always been supportive throughout the completion of this research paper.

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LIST OF SYMBOLS AND ABBREVIATIONS

DOE	:	Department of Environment
ESWIS	:	Electronic Scheduled Waste Information System
SW	:	Scheduled Waste
EQA	:	Environmental Quality Act
EQ(SW)A	:	Environmental Quality (Scheduled Waste) Act
E-waste	:	Electronic / electrical waste
EMS	:	Environmental Management System
OS	:	Operating System
UI/UX	:	User interface / User Experience
AS	:	Android Studio
WTE	:	Waste-to-energy
ESM	:	Environmentally sound Management
FSC	:	Forest Service Council
JV	:	Joint Venture
APP	:	Application
GMS	:	Google Mobile Service
iOT	:	Internet of Thing
IR	:	Industrial Revolution
Ai	:	Artificial Technology

CHAPTER 1 :
INTRODUCTION

1.1 Background of the study

Malaysia has around 6.89 million households in 2020 compared to 6.35 million in 2010 (*Pendapatan dan perbelanjaan isi rumah m40 dan b40 mengikut negeri*, 2020). This increase in total households has contributed significantly to the number of waste generation per year. With each household having literally same basic consumption in daily activities, it is found that most of the household scheduled waste generated are used fluorescent / LED lightings, used wires and batteries, leftover paint, solvent residue, used cooking oil, and pesticide substances. However, the process of collecting scheduled waste from households currently remains unavailable. For companies and factories, the process has been made clear by Department of Environment (DOE) through the gazetted scheduled waste regulation 2005 and supported by the environmental management system 14001 (EMS). All scheduled waste from factories and companies are managed online through the Electronic Scheduled Waste Information System (ESWIS) web system, which covers the reporting and collection process. However, households, which produce roughly 70,000-80,000 tonnes of scheduled waste per year in Malaysia (*Environment Statistics*,2020), are not entitled to use the ESWIS and therefore need another online collection system as well. An online collection platform will terminate the needs of households to go outside the house to send the waste, and instead, they just wait at their house for the waste to be collected by approved DOE contractors. This saves time and money for households since their scheduled waste will be collected properly in a timely manner. Therefore, moving into the future with increasing number of new households every year, there is an urgent need to address the generation of household scheduled waste and devise a proper procedure to collect it from households through a systematic online collection system.

1.2 Statement of Problems

On average, approximately 5,833 tonnes of scheduled waste are generated every month from households (*Environment statistics*,2020). This number keeps increasing every month and year, aligned with the increasing number of new households per year. The problem arises when there is no proper guideline and procedure for households to have their scheduled waste collected and sent to a prescribed treatment premise. Unlike industrial practices among factories and companies which have their own online scheduled waste management system called ESWIS (a system provided and monitored by the Malaysian DOE), households apparently do not have any system to properly dispose the waste. There is, however, collection centres held by local municipal councils. However, the far distance of the collection centre makes it less attractive and time consuming for households. Hence, there is a gap for households in reporting and disposing their scheduled waste to be collected and transported to a prescribed treatment facility. Due to this, some scheduled wastes have been disposed directly into public drainage, rivers, and lakes. The clogging of scheduled waste in public drainage have contributed to flash floods, bad smell and breeding of the Aedes mosquito, as well as contamination of chemical leakage from electrical waste(e,g, battery). Moreover, the disposal of scheduled waste (such as used cooking oil) into rivers and lakes lead to the destruction of aqua life because of the oil characteristic that disrupts oxygen intake.

The total scheduled waste generated every month from households is expected to reach 10,000 tonnes in 2030. With the predicted current collection percentage around 20% from households, it is the most suitable time to introduce a proper procedure and system to collect this waste to prevent it from being released into the environment. The proposed online collection system, together with cloud-chain network, are going to be tested at selective area to study its feasibility. The collection system is targeted to increase scheduled waste collection percentage by at least 5-10% every year.

1.3 Research questions

i. What are the current issues with scheduled waste generation among households?

ii. How does online scheduled waste collection system implementation reduce environmental related impact?

iii. How the effectiveness of online system for scheduled waste collection can be measured?

1.4 Aim of the work

The aim of this work is to create a sustainable online system for collecting scheduled waste from households through the usage of online platform. Since the majority of people use handphones for their daily activities, it is suitable for this system to be online-based and user friendly so that everyone can use it at locations with internet coverage. Moreover, by collecting these wastes, we can contribute towards a better future and sustainable green environment for our future generations.

1.5 Objectives and scope of the work

The scope of development of online scheduled waste collection platform is to create a systematic approach in managing and collecting scheduled waste from households. Therefore, the main objectives of this research are listed below :

1) To determine issues related to scheduled waste collection from households.

2) To develop online scheduled waste collection system for households.

3) To conduct validation of the system in a selective housing area.

1.6 Significance of the work

The work will be very significant in scheduled waste management in the future. Currently millions of kilograms of scheduled waste are generated from households every month. Some of these wastes are collected and sent to treatment centres or landfills, while others are thrown into public drainage, rivers as well as lakes. By doing this project, it is hoped to achieve a reduction in waste disposal into environment by at least 5-10% per year and systematically manage scheduled waste generated from households.

1.7 Dissertation outline

In a nutshell, this study consists of 5 chapters as follows:

i. Chapter 1 – Introduction

This chapter covers the background of the research a brief information on types of scheduled waste which is being collected from households, types of scheduled waste that cause environmental pollution, the current management of scheduled waste and projected waste generation in 10 years' time. Besides, this chapter also discusses the problem statement, aim and objectives of the study and scope of the study.

ii. Chapter 2 – Literature review

This chapter discusses previous and current findings on scheduled waste and how waste generation from households pollute the environment. Apart from legal requirements in controlling the illegal disposal of waste into the environment, this chapter also reviews the current practices of scheduled waste management in Malaysia and other countries. Discussions on new technology and mobile app are also highlighted here.

iii. Chapter 3 – Research Methodology

This chapter explains the various techniques and methods used in gathering data and information which is relevant to this study. Among the method usedare site visits, interviews and system testing at selected housing areas. All the information gathered are analyzed for the possible implementation of online collection system for households. Coding of the mobile app was conducted by a professional software engineer based in Pakistan.

iv. Chapter 4 – Results and Discussion

This chapter involves results obtained by implementing online scheduled waste collection system from households. A mobile app specifically built for the system will be further tested and discussed in this chapter. The effectiveness of online system implementation was measured by the total scheduled waste collected and treated at recovery facilities. The barriers and challenges on the implementation are also reviewed accordingly.

v. Chapter 5 – Conclusion and Recommendation

This chapter summarizes overall findings from development of online collection system approaches in managing scheduled waste from households while assessing if the initial objective was met. Suggestions and recommendations for future studies will also be highlighted in another segment of this chapter.

CHAPTER 2 :
LITERATURE REVIEW

2.1 Scheduled waste generation from households

Humans will always produce waste because of their daily activities. There are many types of waste to begin with. Ideally, it is divided into two types: hazardous type and non-hazardous type. The non-hazardous waste type can be something which is not harmful to humans. For example, food waste, used perishable items, drink cans, tissue and others. As for hazardous waste, also known as scheduled waste, it is a type of waste that can be harmful to humans or the environment. Items such as oil waste, used batteries which contain cadmium or mercury, faulty thermometers, toxic chemical residue, leftover pesticide substances are some of the hazardous wastes normally generated by people. Even though industrial factories will produce a lot more scheduled waste due to their industrial activities, we can't neglect that households too generate waste as resulting from their daily activities. Most household wastes are normally non-hazardous type such as food waste, used diapers, tissues, used groceries and others. These wastes are usually picked up weekly by a dump-truck contractor appointed by the local municipal council. However, there is an issue when it comes to scheduled waste. It is found that scheduled wastes are also mixed with other solid wastes when thrown into the dump-truck. A dump-truck operator is not tasked to check the waste before pickup and they send it straight to the landfill nearby. In Malaysia, we have roughly 167 landfills nationwide(Zaini,2010). From this, only 6 are categorized as sanitary landfills and others are just classified as 'open dumping' sites. What exactly is a sanitary landfill? It is a systematic landfill which is properly planned and equipped with proper machines and tools. These sanitary landfills also follow global standards in operation procedure. They have characteristics such as leachate collection system, membrane covers, harmful gas reducing equipment, water drip pipe collector, moisture sensors and others. Some sanitary landfills are equipped with the latest machines which can segregate metal and composite material from the mixed waste. The biggest and most advance sanitary landfill in Malaysia is located in Bukit Tagar, Selangor.

However, the remaining 161 landfills are merely scarce land without any equipment or systems. It is as akin to an open dumping site, without any systematic waste residue collection or gas detection sensors. The mixed waste that produces huge amounts of leachate will gradually be absorbed by soil into groundwater, subsequently polluting the groundwater in the long term. Groundwater or 'air telaga' has been used extensively especially among villagers for their daily activities such as washing clothes, farming and even drinking. Nevertheless, the harmful methane and carbon dioxide gases that are produced from landfills are a threat to nearby communities. It is good to know that these 2 gases represent 98% of gases produced at most landfills. Methane is known to trap heat 80 times more than carbon dioxide and is highly flammable. Methane when mixed with air and introduced with spark would result in burning throughout the mixture, which can be described as explosive. Every landfill is required to be at least 10 kilometres away from nearby communities to reduce the chances of accidental ignition and explosion which may threaten people.

Mixed waste which contains organic material exceeding 20% should be segregated and sent to incinerators before being dumped into landfills. However, not all landfills conduct this process, only sanitary landfills and those nearby incinerator plants perform this procedure. This is because, waste with high levels of organic material would result in more moisture dripping out to the landfill and becomes leachate that seep into the soil. Therefore, incinerators will burn these high organic wastes to overcome the moisture issue. There are currently 7 incinerator plants in Malaysia, located in Langkawi, Pulau Pangkor, Pulau Tioman, Cameron Highlands, Labuan, Semenyih and Negeri Sembilan. Out of these, only Semenyih and Langkawi plants adopt thewaste-to-energy (WTE) approach of incinerating municipal waste. The waste, incinerated at high temperatures of more than 800ºC, is used to produce steam which drive turbine generators. The generator then produces gigawatts of electricity to be consumed nationwide. It is a good indicator that finally municipal waste can be beneficial to both human and the environment in creating sustainable green energy instead of relying on coal-powered electric plants.

A list of scheduled wastes is provided by the Malaysian DOE in First Schedule, Regulation 2, Environmental Quality Act (Scheduled Waste) 2005. There are 5 categories of scheduled waste in the First Schedule. From the schedule, main scheduled waste from households that have been identified are tabulated below:

No.	List of Scheduled Waste	Code of Scheduled Waste (Based on First Schedule, EQA(SW)2005)	Percentage in Households
1	E-waste ✓ Used fluorescent / LED Lightings ✓ Used plugs, fuse, connectors, wires ✓ Used batteries ✓ faulty electrical and electronic components or device	SW 110 / SW 103	10-15%
2	✓ Used cooking oil / spent lubricants	SW 305 / 311	80-85%
3	✓ Paints / solvent / dye / lacquer	SW 417	1-2%
4	✓ Pesticides / Insect spray	SW 425	1-2%

Table 2.1 : Scheduled waste breakdown from households

From the above table of common scheduled waste generated from households, used cooking oil constitute the majority of generated waste with 60,000-65,000 metric tonnes per year (*Environment statistics*, 2020), which is around 80% of total scheduled household waste. Second most generated are ‘e-waste’ which

comprise approximately10-15% of total scheduled waste (Fatihah Suja et al, 2014) and the rest are other types of scheduled waste such as leftover paints, pesticides, clinical waste, etc which is around 5-10% of the total waste.

2.2 Regulatory requirements and compliance level in Malaysia

Any scheduled waste generated is subjected to Environmental Quality (Scheduled waste) Act 2005. Among key details in the regulation are:

i) Any scheduled waste from premise or factories must be treated or disposed with proper procedure and handling.

ii) Scheduled waste must be treated or disposed at prescribed premises licensed by the DOE.

iii) Proper handling during transportation and managing the waste by using suitable PPE such as glove, facemask, goggle, shoes depending on the type of waste.

iv) Premises shall not store more than 20 tonnes of waste at one time and not exceeding 180 days of storage duration.

v) Transportation of the scheduled waste must be done by approved and licensed contractors

vi)Any scheduled waste information such as characteristics, physical properties, safety precaution, and emergency response procedure must be made available in the waste-card and label.

The compliance level for companies and factories were estimated to be at 80% as per DOE inspection. However, the compliance level for households stood at less than 20%. It is targeted to achieve at least 70% by 2030.

2.3 Challenges and issues for managing schedule waste generated in households

The number of Malaysian households have increased steadily since the Declaration of Independence in 1957. Currently, Malaysia has roughly 6.89 million households in 2020 as per data provided by the Malaysian Department of Statistics (DOSM). The number will keep increasing every year and therefore, it makes managing scheduled waste from households more challenging. However, the main challenges and issues mostly revolve around these 2 topics: public awareness and collection method.

2.3.1 Challenges and issue on public awareness

Households are increasingly growing in number every year. 6.89 million households in 2020 is not a small figure, with population scattered mainly in urban areas, and the rest in rural areas. Among the main challenges are to educate households of the importance of scheduled waste disposal at the right place. Not all waste generated in households are considered scheduled waste. Some solid waste such as food and plastics are not considered as scheduled waste even though the latter can be recycled. This solid waste will normally be collected by a landfill dump-truck and some will be filtered and goes into an incinerator, depending on the level of organic content. Educating households require consistency and public involvement. The Basel Convention 1992 has been the key point where the Malaysian government started to actively involve local municipal councils in managing scheduled waste from households. Local masterplans that focus on increasing public awareness regarding the harm of scheduled waste, its effects and how to handle it were drafted and enforced. Activities that have been done by local municipal council to educate the public include continuous seminars, awareness roadshows, circulation of flyers and advertisements as well as house-to-house promotions.

Several scheduled waste collection centres combined with recycling centres have been introduced around housing areas as a disposal point. Special collaborations haves also been done with corporate entities such as Fathopes Energy Berhad where the disposal of used cooking oil among

households were given monetary incentives, and this has greatly increased the involvement of households in storing their used cooking oil. Further initiatives have also been followed by several other corporate entities such as Alam Flora and Berjaya Eco company with more municipal councils nationwide.

2.3.2 Challenges and issue on household collection

After the Basel Convention 1992, the government through local municipal councils started educating households on the importance of handling and disposing scheduled waste at the right place. More households involve in storing and sending their scheduled waste especially used cooking oil and electronic waste to independent collectors which are later treated at a prescribed private treatment facility. More collection centres have been built to subsequently increase the collection activity. However, the issue of scheduled waste dumping into drainage and rivers persists. The founding of used oil in the drainage sewerage system still occur in urban and rural areas. Even other scheduled waste such as electronic waste and chemical residue are found mixed with solid waste in the landfill. This issue requires a quick solution in the future such as an onsite collection directly from households because sometimes the collection centre is too far. With more people working two or three jobs at a time, it could be ascertained that most of the time people will be outside of the house except for housewives and kids at home. Apparently, it is not convenient for a housewife to leave the kids in the house just to deliver the scheduled waste. Until recently, there is a growing number of independent scheduled waste collectors in the urban district, albeit not at all areas. Usually, they are 'freelancers' and are not available on a daily basis. Due to this, the simple and fastest way would still be the traditional way; throw it into the dustbin, or worse into drainage systems and this must change.

2.4 Best practices from other countries in managing household hazardous waste

Many new technologies to manage household scheduled wastes have been introduced in other countries. As example, China introduced a waste-into-clothes technology to convert solid waste into wearable clothing. The process involves scrapping waste in solid form, from e-waste or plastic, put into special machine together with specific additives to produce main material for the textile industry. Not only are the new material comfortable and elegant, it is also cheap since it is taken from waste material. Moreover, it is good to the environment since the process of producing cloth material such as cotton, silk and fabric require high electricity consumption.

New technology from university research teams have also contributed towards reducing household scheduled wastes. A university in the UK has first found the way to make biodiesel, an alternative to diesel, from the household used cooking oil. As every household use a considerable amount of cooking oil every month for deep frying and cooking, the accumulation of used cooking oil has created an opportunity for biodiesel to be used widely for diesel engines especially in commercial vehicles. As example, all Mcdonald's trucks in the USA have been using 100% biodiesel as part of the company's initiative to reduce carbon footprints. In Malaysia, local petrol stations have started to offer biodiesel from September 2021.

In Japan, the household scheduled wastes can be disposed at automated self-service collection centres nationwide. The centre, equipped with the latest touch screen self-service system, will instruct the user to put the waste into the steel box provided. It will open and close automatically, equipped with digital sensors. Once the container is full, the system itself will send a reminder to a nearby waste factory to collect the item as soon as possible.

2.5 Current developments in managing scheduled waste in Malaysia

Currently the Department of Environment (DOE) is leading the way in enforcing scheduled waste regulation in Malaysia. Public roadshows, onsite seminars, online consultations were conducted on a regular basis to increase awareness of the importance of managing scheduled waste. More licensed transporters and recovery facilities have been approved in recent years that have been updated on the DOE website. The transfer of technology from other countries such as Japan has been matched-up with local companies to embrace the technology locally such as done by Amita Berjaya Sdn Bhd, transforming 15 types of scheduled waste into useful material (such as cement replacement material) without any chemical, water and additives involved. Moreover, scheduled waste from oil-type such as used cooking oil, engine oil and used lubricants have been found to be very useful for road building. Combination of road tarmac, asphalt, gravel and used oil has been utilized to increase the durability of the roadworks.

The new direction of managing scheduled waste today is to convert it into green energy. Our gigawatt electricity generator plants that have long been using coal and gas as its main catalyst have greatly affected the environment. A lot of carbon dioxide and harmful gases released during the electrical generating combustion process has been detrimental to the ozone layers as well as increasing the global warming effect. New technology to convert scheduled waste has been found to decompose scheduled waste to generate electricity. For example, electronic scheduled waste (e-waste) parts which can’t be recovered will be decomposed at high temperature and subsequently release highly flammable gases together with some harmful gases due to the chemical reaction. The harmful gases will be neutralized and absorbed through advance Local Exhaust System (LEV) technology. Those highly flammable gases however are used in the combustion process to generate new electricity. This is indeed a good replacement for coal and gas-powered generator plants as a way to embrace green technology in our country’s grid electrical supply.

2.6 Available management system in Malaysia

In Malaysia, the primary management system available for waste-related handling is the Environmental Management System 14001 (EMS) as a main guideline for local companies in managing industrial waste. It covers all documentation requirement from systematic filing system, record keeping, characteristics of storage area, containers as well as disposal methods for the waste. It is applicable as well to households; however common households will find it difficult to fully understand the points in the management system due to lack of knowledge or being simply untrained in this area. This is where the gap must be identified and simple guideline for non-industrial people can be initiated. At the moment, there are no specific management systems available for the households.

Another management system that is related to the scheduled waste is the ISO 14040(2006) Environmental management: Life Cycle Assessment. Through this system, the Life Cycle Analysis method is adopted to calculate and determine the impact of certain products to the human and environment throughout its lifetime. A product will be analysed starting from their raw material sourcing, transportation throughout the production process until end user utilization, manufacturing process, lifetime shelf-life calculation, as well as post-life conditions. This is a very powerful system that not only determines the effect of each product to the environment, but also its impact to the economy and nation development.

A famous example of the utilization of this powerful system is by Coca-Cola. Earlier in year 2000, Coca-cola has been in dilemma whether to continue using glass-type packaging for their drinks or to convert to latest aluminium-can / HDPE bottle packaging. They hired a consultant company to thoroughly analyse all Coca-Cola products globally and the impact and effect of changing their packaging through the Life Cycle Analysis method. The consultant company took more than 2 years to analyse, precisely calculat and determine the impact and effect of changing the type of Coca-Cola packaging, to the extent that Coca-Cola saved a few billion dollars in transportation and logistics costs globally. Not only that, they also reduced the carbon footprint in their manufacturing process and vehicle exhaust emission which is vital for environmental sustainability.

As of today, EMS 14001 has been supported by two additional sub-systems; namely Environmental Management System (EMS)14010: Environmental Audit and Environmental Management System (EMS)14020: Environmental Labelling. Through

EMS 14010, the importance of environmental audit to be done from time-to-time to ensure procedures and guideline of the main EMS 14001 are embraced. It provides the guideline for environmental audit, its methodology, qualification of the auditor and detailed process of the audit. It is important as it ensures human activity especially industrial practices do not harm the environment in the long term. It is also to determine the level of effluent discharged at the time of audit and to quantitatively measure its impact on the society.

EMS 14020 focus more on the labelling of products fully manufactured with environmentally friendly material. For example, Forest Stewardship Label (FSC) for wood products is the highest certification given to this type of product. FSC is an international, non-governmental organization dedicated to promoting responsible management of the world's forests. FSC has developed a system of forest certification and product labelling that enables people to identify responsibly sourced wood, paper and other forest products. In today's time, the McDonald's chain restaurants have been among the big enterprises that have FSC certification on their food packaging.

Figure 2.1 : Global FSC logo

In Malaysia, we have local Sirim Eco-label certification for products that have been produced by strict eco-friendly criteria. In this certification, Sirim has created two eco-label requirements for producers: Sirim ECO 001:2016 Degradable & Compostable Plastic Packaging Materials and Sirim ECO 009:2016 Biomass-Based Products for food-contact applications. All plastic sheets and films in the form of bags or packaging materials must fulfil the Sirim ECO 001:2016 specifications. The Sirim ECO 009:2016 criteria were developed to be applied with biodegradable and compostable biomass-based products that can be used for food serving and packaging. Consumers are offered safe, dependable, and environmentally friendly

products while also contributing to the preservation and protection of the environment by getting the products approved under these Eco-labelling scheme.

Figure 2.2 : SIRIM Eco-label Logo

2.7 Issues with current management system for households

Some common issues for the households is the ability of the households to understand the points written in the management system. Some educated people in the industry would understand, while others will find it hard to digest due to a lack of knowledge and experience. The technical terms in the management system will require some explanation to the households to improve their understanding. This is where an info-graphic or pictorial with simple explanations regarding the environmental management system are beneficial for the households. The usage of pictures and icons will also make it more understandable and interactive, and it can also attract kids to learn and embrace it in the future.

Some households did not really understand the definition of eco-label certification and its importance to the environment. Currently, Sirim is working hard to encourage companies to get the certification of Eco-label scheme, while educating the households to prioritize product with eco-label logo in their grocery items. Some household daily items such as asbestos packaging (cup, bowl, food containers, etc) and non-degradable plastic packaging have been successfully converted into environmentally-friendly material such as using composed sugarcane and potato-based material for product packaging. These eco materials are recyclable and not harmful to the environment.

2.8 Scheduled waste life cycle analysis

The regular process of scheduled waste usually follows the path of cradle-to-grave method. It means the end-product of scheduled waste will usually be disposed in landfills and buried there until it decomposes. However, with the latest advancement in technology, the concept has changed into cradle-to-cradle method whereby the end-product of scheduled waste will be recovered or treated back into useful material. As example, used cooking oil has been treated and transformed into biodiesel, soap and cosmetic substance. Instead of being disposed in landfills and creating mountain of waste piles, finally scheduled waste can be reused and recovered. As for that, the scheduled waste will go through several stages of processes during its life cycle.

2.8.1 Recovery and screening process

Scheduled waste from households will normally come from two sources; municipal waste or local collection centres. Scheduled waste from municipal dump-trucks are harder to be segregated because it is mixed with other solid wastes such as food or used plastic packaging. Some of the valuable substances recovered from this process are non-ferrous metals such as copper and aluminium and precious metals such as silver, gold, platinum and palladium. It is worth to note that during the Japan Olympic Games 2021, roughly 2 million metric tonnes of electronic scheduled waste have been recovered and used to make 5000 Olympic winners medals consisting of gold, silver and bronze medals.

2.8.2 Treatment process

Some scheduled waste will to the treatment facility to be converted from hazardous to non-hazardous material. While there is certain scheduled waste especially oil-based type that can be extracted and turned into chemical additive that can be used in many consumer industries globally. For example, oil-based scheduled waste such as used cooking oil has been extracted to produce diethyl-esther that is important in producing soap, detergent, cosmetic and biodiesel.

2.8.3 Land disposal & incinerator process

For the remaining scheduled waste that can't be recovered but have been transformed into non-hazardous substance, they will finally be disposed at regular landfill or taken to WTE incinerator to produce new electricity.

2.9 Scheduled waste revenue model

2.9.1 Revenue from municipal council

To sustain the usage and maintenance of the system, a sustainable revenue must be made to pay all costs related to the system such as server fee, technical maintenance, cloud-chain charges, logistics expenses and others. The first stream of revenue could come by taking contract collection jobs from local municipal councils. Every year, each municipal council will be given a budget for local waste collection jobs. These are done normally by dump-truck contractors which pick-up the general waste from house to house and send them to landfills or incinerators. By proposing to local municipal councils on the importance of segregating and treating scheduled waste, they will accept the contract to use the system in the long term.

2.9.2 Revenue from treatment plant

Other revenue streams could come in the form of payment from the treatment facilities. Since these wastes can be recycled and transformed into new products, a payment based on weight of waste collection could be incurred. Currently, a biodiesel plant ipays up to RM3.50 per kilogram for used cooking oil. It is a lucrative market and also good for the environment. For other types of scheduled waste, the traded price is around RM0.50-1.50/kg.

2.9.3 Revenue from corporate Joint-Venture (JV)

Certain big companies such as Petronas and Sapura have their own annual sustainability budget to be spent in improving environmental impact and sustainability initiative of their businesses. Scheduled waste from households have the potential to be used as material replacement substances in their factory. This creates cheaper cost of product and cleaner environment by reducing new resource utilization. Currently, new research and development have been ongoing to produce new technology from

wastes. For example, used cooking oil has been in research to find potential of chemical additive replacement in petrochemical industry.

2.9.4 Revenue from foreign oversea importer

Although in Malaysia we have less scheduled waste treatment plants, in countries such as the USA, UK and Japan have been key players by having most of the advanced treatment plants there. They have ISCC Europe standards with the main focus is to set a standard of cleaner production processes, eco-friendly material and renewable energy utilization. At the moment, the USA is the main importer of biodiesel worldwide. In southeast Asia, only Indonesia has been the key exporter of biodiesel-based products, which until now has been in short supply because of the high demand from European factories. Japan is now importing more and more electronic scheduled waste to be utilised in their waste recovery plants after the successful initiative of extracting gold, silver and bronze to create medals for their Olympic games.

2.10 Literature review summary

Scheduled waste generation has gradually increased among households every year. The rampant illegal dumping of waste at local amenities has been a threat to the environment as well as human beings. A robust collection and treatment system must be initiated now rather than later to curb the growing mountain piles of scheduled waste in the future. The study of an online system to handle scheduled waste from households seems to be the answer for the growing of illegal dumping of these waste into public infrastructure. Not only that, much bigger benefits have been found; the creation of green energy from waste and green technology such as biodiesel and waste-to-energy incinerators. More countries are researching in latest green technology and many efforts have been done to encourage collection of scheduled waste from households. With the latest trend in green batteries and renewable energy such as housing wind panels, the concern has shifted into how these electronic scheduled wastes will be handled in the future. Will these wastes still end up in landfills and create 100 million tonnes of scraped parts in 2030? Or will normal practices of dumping used oil into kitchen sinks still exist then?

CHAPTER 3 :
METHODOLOGY

3.1 Overall methodology

The development of the online schedule waste collection system will be staged into three phases. The first phase will focus on drafting standard operating procedure (SOP) for collecting scheduled waste from households. Then after finalizing the SOP, development of online collection system will be built based on the household's findings and legal requirements. In the third phase, the online system will be tested at selected housing areas for system validation and usability. The system will be enhanced and rectified based on the testing results at the selected housing areas.

Part of the drafting of the system's SOP will focus on key metric elements such as households scheduled waste loading and unloading process, criteria of scheduled waste container, physical characteristics of transportation vehicle, warehouse process flow as well as legal obligations. Safety precaution aspect will also to be taken seriously to avoid any incidents during the collection and handling process.

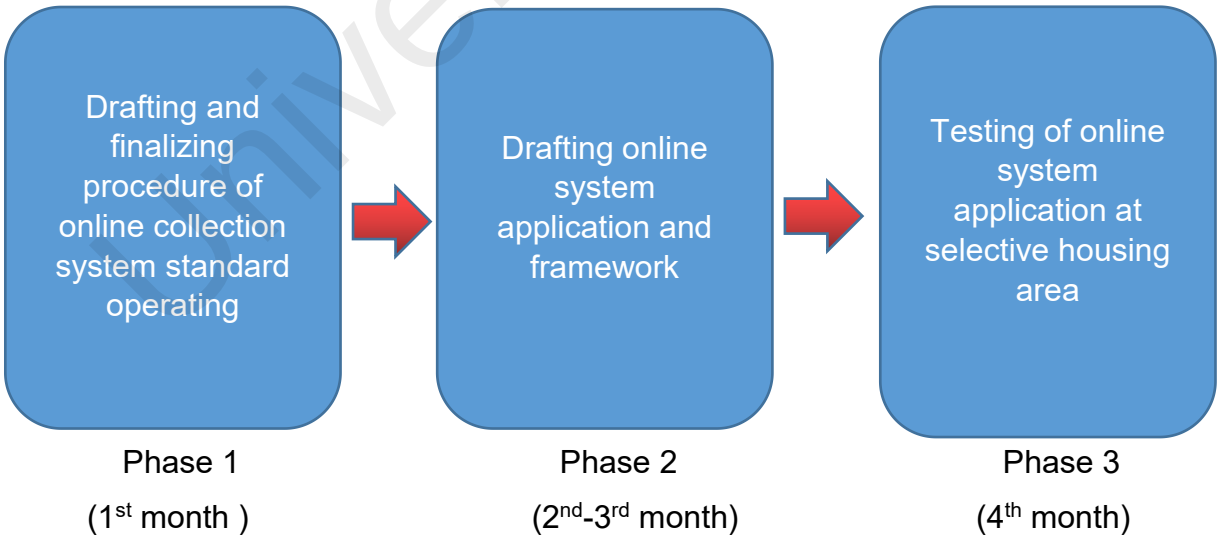

Figure 3.1 : Three phases of system development

The core element of the research will be during the building of the online system framework. The online system will be built on mobile-based android or iOS frameworks, depending on the complexity of the procedure and process flow. As comparison, web-based framework, especially those using Java or HTML programming, are easier to build compared to mobile applications (which used Flutter or IONIC programming code). In terms of costs, a web-based system is cheaper compared to a mobile application. It is because a mobile application has more complex programming code than a web-based system. However, a mobile-based system has more functionality and better accessibility, making mostpeople to favour the use of mobile applications rather than surfing a website.

The system process flow is an important piece of documentation in implementing an online system for households. This flow gives detailed information on the steps needed to be taken to ensure the successful collection and handling processes. It comprises of three sides: user, partner-collector, and warehouse management. Each of them will play their roles in ensuring the collection of scheduled waste in smooth and safe manner.

With the emergence of latest technologies in cellular 5G and metaverse, households expect simple and easy solutions for the system to be implemented. A collection booking that can be booked under 5 seconds would be a great advantage, The use of latest technologies such as RFID and NFC tagging systems would be beneficial in handling thousands of waste containers especially in warehouses. Lastly, the important role of partner-collector to ensure each household are monitored in term of their waste collected will be a key indicator to sustainable scheduled waste collection in the future.

3.1.1 System process flow

1) A user or household registers a new account and login into the system application. They can choose which type of scheduled waste to be collected. Then finally book specific date/time for the scheduled waste to be collected at their house.

2) Collector-rider will then collect all the waste from households, store it properly in the transport, and send it to an instructed treatment facility endorsed by the DOE. Collector-rider will get payment based on how many kilograms of scheduled waste sent.

3) The user will get reward points for each successful waste collected from them. There will be a milestone to achieve certain rewards. They can see how much quantity of waste they have saved in their booking history in the system.

4) Back-end system will compile all records and analyse its pattern. A weekly comprehensive report will be produced every Monday. A detailed report will be shown in the administrator panel which shows rate of successful collection, percentage of scheduled waste types collected and many more.

Figure 3.2 : System process flow

3.2 Framework to develop online system

Just like a house, an online system framework in a mobile application is divided into 3 parts; front-end, back-end and administrator panel (dashboard). The combination of these 3 parts make up a typical mobile application system that we normally use nowadays. A breakdown of any one of these parts will result in the entire system to be unusable.

3.2.1 Front-end system

The front-end is like the front door of a house. It is where the user interacts the most. In this context, the front-end basically will be the interface that users or households will be able to book a collection date for their scheduled waste. To build the front-end, application programmers normally use Flutter, React, App Studio or IONIC coding languages. These coding languages are widely used in mobile application development worldwide.

3.2.2 Back-end system

In the back-end, it is the source file of the system which connect the database into cloud-chain network as well as server configurations. Think of it as the foundation of a structure, it is the important part that liaise the interaction between user, records, cloud-chain, information processing and operation speed. A strong bank-end system will ensure that the front-end runs smoothly. Most back-end systems in the world today are using Ruby and Python coding language.

3.2.3 Administrator Panel or Dashboard

Between the front-end and back-end of an online application, the administrator panel is the bridge that connects the front- and the back-end. It is the management panel of a system, just like a company whose managed by amanagement board. The function of an administrator panel is to summarize data collected from front-end and back-end, analyse it and portray it in info-graphic form to the system administrator. The administrator panel as well configure the general setting of the system.

3.3 Validation methodology

To validate the usage of the online collection system, a series of hypothesis testing will be done at selected areas. Several households will be picked, based on area and type of housing. Testing will be done in 2 types of housing area which are terraces and apartments. A sample of 15 households will be chosen randomly, and each of them will be interviewed and briefed on the system for 30 minutes. The questions will focus on households' typical channel of disposing scheduled waste, type of containers used in the households, some input in households' activities that result in waste generation as well as major issues and problems in their current scheduled waste collection. The system validation scripts are shown below:

System Validation Script Interview

WARM UP CONVERSATIONS

Let me introduce myself.. my name is Azree, from Uni Malaya. I'm doing a quick validation study on scheduled waste collection from households. It wont tak long and hopefully we try to end this as fast as we can.

WARM UP CONVERSATION

Can you tell a little bit normally what you do at your house daily?

Based on the data from Jabatan alam sekitar (DOE), there are a lot of cases where harmful waste such as used cooking oil, chemicals and pesticide that disposed into drains and rivers.. and even to sink..

TRIGGER ISSUE CONVERSATION

Can you tell me why this thing happen?

Have you ever done that?.. don't worry, this survey is confidential.

How do you think that this thing will end? And people stop disposing into sink and drains or garbage truck instead of recycling? As example, people send to recycle centre or segregate their waste.

SOLUTION FINDING CONVERSATION

Why is it difficult to do that?

Based on your answer just now, is there anything that you do to solve that problem currently?

And is it costly? Can you share how much you spend on it?

Specific validation hypothesis.

VALIDATION CONVERSATION

1) Before today, have you sent the scheduled waste to recycle centre?
2) Is the recycle centre far from the house?
3) Are you comfortable and will go again to the recycle centre?
4) Have you ever used scheduled waste collector service?
5) How convenient you to contact the scheduled waste collector service?
6) Are you having enough container to store waste?
7) Is it a must to be given a free container to store the scheduled waste?
8) Do you prefer usage of mobile app to collect wastes over existing methods?

3.4 Selected site for trail

Shah Alam will be chosen as the selected site for the testing trail. The reason is because the variety of housing types available, mixed community comprising multiple races, and last but not least the short distance to the scheduled waste treatment facilities which are located at Seksyen 32, Denai Alam and Kampung Melayu Subang. To ensure demographic acceptance, 2 series of testing will be done at 2 locations with different types of housing, which is terrace and apartment. 30 respondents will be chosen randomly to test the system validation.

Legends:

Blue Marking - Centre of Shah Alam

Light Green Marking - Location of scheduled waste treatment plants /facility

Black Border - Area of test coverage

Figure 3.5 : Coverage Area and treatment plant locations

3.5 Method for evaluating the performance

To determine the performance of the online collection system, a series of key metrics will be monitored on a daily basis at the selected testing sites. The result will be determined by percentage of successful booking and collection rate, rate of repetition and quantity of scheduled waste collected.

3.5.1 Successful booking and collection rate

The performance will be evaluated by consistency of successful booking and collection of the scheduled waste. Success rate depends on how many percentages of scheduled wastes are properly collected, stored in a proper transport and lastly sent over safely to a prescribed treatment facility approved by the DOE.

3.5.2 Repeat collection rate by households

In order to encourage continuous collection from households from time to time, a periodical check-up will be done. If a household didn't continue using the online collection system after the first booking, an interview will be done with the household to get feedback and why the reason they didn't use it after the first time. From that, we will know the system's weaknesses and will try to improve the issues based on the feedback given.

3.5.3 Quantity of scheduled waste collected

A monthly and annual quantity target for scheduled waste collection will be imposed. This is to ensure the system solves household problems and simultaneously reduce disposal of scheduled waste into drains and public amenities. Initial target of 1000 kilograms per month is expected, with increment to 10,000 kilograms in the next 6 months. However, the numbers will also depends on household demand and coverage area. If the numbers are not achieved for 3 consecutive months, a system review will be done to know the limit and maybe hick-up. If the numbers are outnumbered for 3 consecutive months, a new and bigger warehouse will be built to cater the demand and supply.

3.6 Proposed system

An online system using Flutter 2.0 programming code is proposed for this project. Flutter 2.0 is a programming code developed by Google to ease software programmers in creating high functionality mobile applications without complex codes. The main advantage of Flutter is that, it can create android and ios mobile applications using a single framework. Unlike other programming codes such as IONIC, REACT and Kotlin, these are harder to build and it only caters for the android ecosystem. Flutter is also very flexible because it can suit with variety of back-end framework such as PHP and Java.

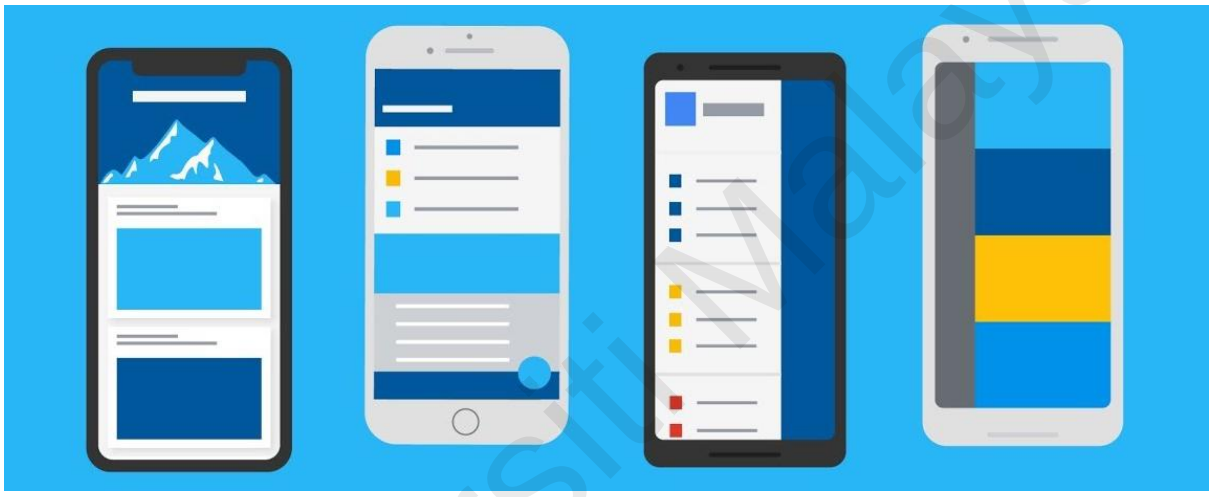

Figure 3.4 : Flutter 2.0 programming user interface

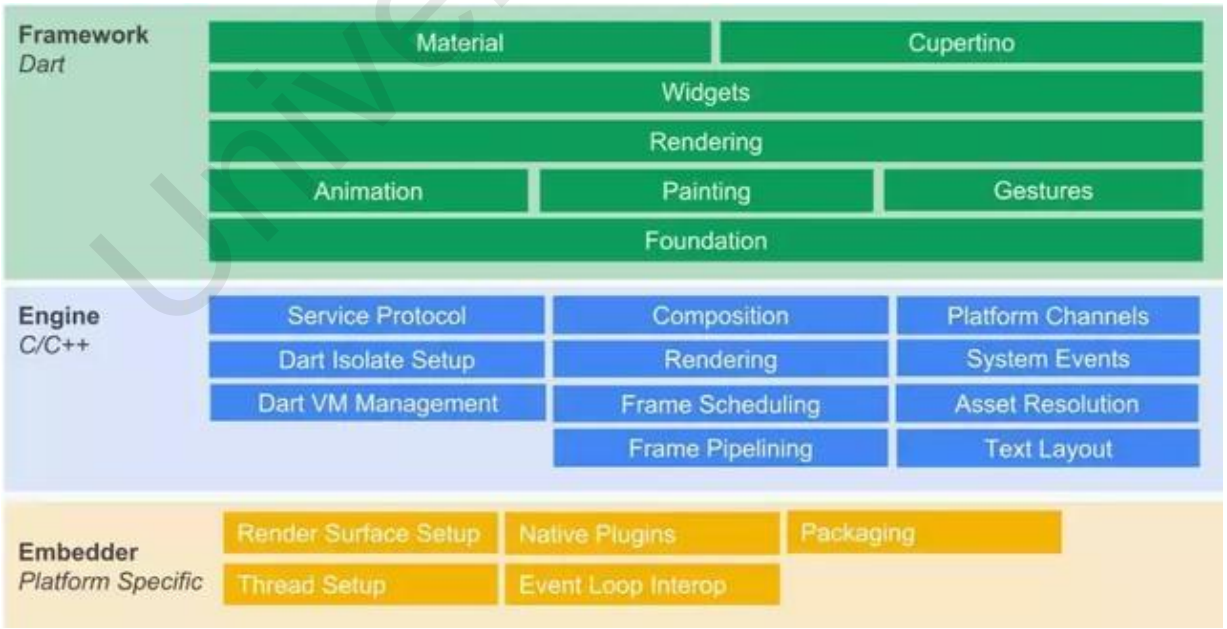

Figure 3.5 : Flutter 2.0 programming code framework

3.7 **Safety precaution**.

As part of safety precaution during public surveys and system testing at selected areas, several safety measures will be taken which focuses on hygiene and contagious disease prevention (i.e., Covid-19) as well as waste leakage and pollution control. The required safety precaution measures are listed below:

i) Usage of tight-proof container made from HDPE plastic to store used cooking oil waste to avoid leakage and contamination.

ii) Collected barrels or containers will be labelled and dated accordingly to avoid mixture of waste.

iii) Usage of hand gloves, 3-ply facemasks and safety PPE during collection process at houses to avoid exposure to danger and disease.

iv) Usage of thick rubber gloves to handle electrical waste to avoid sharp edges.

v) Usage of plastic-rubber buckets to store used paint, lacquer and pesticides/ insecticides to avoid leakage and falling.

CHAPTER 4 :
RESULTS AND DISCUSSION

4.1 Main issues from scheduled waste collection from households and proposed model

On-site study has been done and several key issues related to scheduled waste collection from households have been identified such as:

a) Lack of knowledge on how and where to dispose the schedule waste.

b) Lack of proper channel to engage the right person to handle the waste collection.

c) Complicated communication and procedures to engage service collection from households.

d) No space or containers to put the scheduled waste in the house.

Based on the issues above, a system model was developed to rectify the problems by the households. The model is illustrated below:

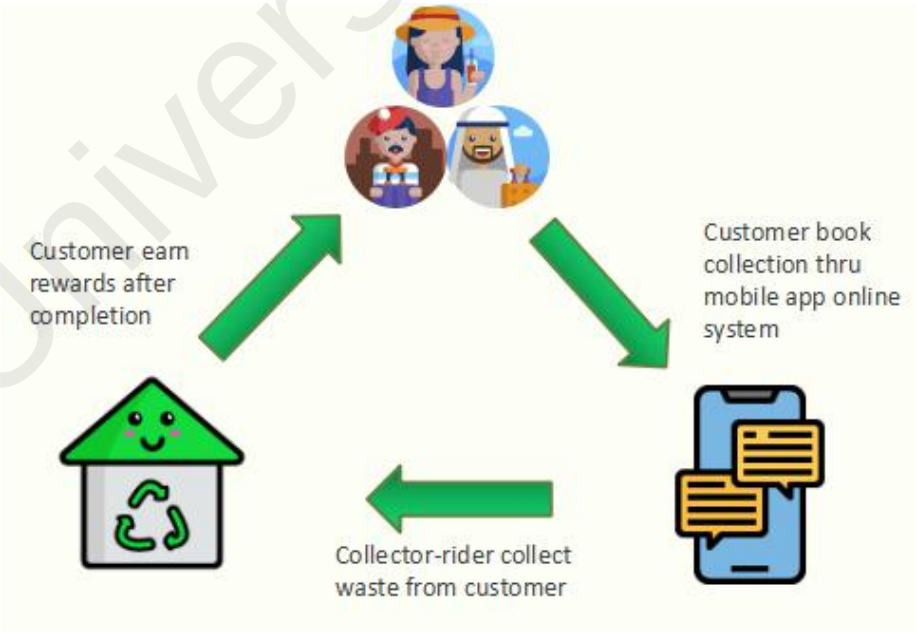

Figure 4.1 : The proposed online collection system model

The proposed model will comprise of three parties: users (households), collector-rider and scheduled waste treatment facility. A collection booking will be considered successful once a user confirms the booking date in the application, a collector-rider (also known as partner-collector) collects the waste and all the wastes are successfully transferred to the warehouse. Upon checking and weighing at the warehouse, the scheduled waste will be stored safely at a designated area. Once storage nears 70% full and below 20 metric tonnes, all the stored scheduled waste will be transported to a prescribed treatment facilities approved by the DOE.

4.2 Validation results

A number of household respondents are interviewed to get a precise validation of the system based on quantification method. The results are tabulated, with each hypothesis listed in numbering form. The end results are analysed and compared with the initial hypothesis to achieve the system validation objective.

"H = Hypothesis of validation"

H1 = Have the respondent send the scheduled waste to recycling centre

- This hypothesis determines whether the household has ever sent their scheduled waste to a recycling centre. From this, we can validate that manual collection to the recycling centre has been done by the household.

H2 = Is the recycling centre far from the house

- To validate the main point of households of sending their scheduled waste to the recycle centres. Will the far distance affect the interest of households to ever going there again?

H3 = Are respondent comfortable and will go again to the recycling centre

- In this point, the key is to validate whether the current or existing method of sending to recycling centre is convenient to households. Are they going to repeatedly go to the recycling centre?

H4 = Have respondents ever used scheduled waste collector services

- Through this we can find out whether households have ever engaged a scheduled waste collector service previously. It also means the respondent is aware of the importance of sending the scheduled waste to the right place.

H5 = Hard to contact the scheduled waste collector service

- This is one of the main point for households. The existing method of engaging scheduled waste through call or whatsapp to be analysed in this hypothesis.

H6 = Do respondents have enough containers to store waste

- One of the reasons for households for not collecting scheduled waste is maybe due to lack of containers to store the waste. This part revealed the validation of this hypothesis.

H7 = Is it a must to be given a free container to store the scheduled waste

- Maybe some households have the tendency to store their scheduled waste when given free containers such as HDPE bottles or drum barrels.

H8 = usage of mobile application to collect waste to be preferred over existing method

- respondents are validated on the usage of mobile application for scheduled waste collection from households are preferable over other methods.

NO.	Respondents Codes	Respondents Validation
1	Household 1	H1 = validated H2 = validated H3 = Invalidated H4 = validated H5 = invalidated H6 = validated H7 = invalidated H8 = validated
2	Household 2	H1 = validated H2 = Invalidated H3 = Validated H4 = validated H5 = invalidated H6 = validated H7 = invalidated H8 = validated
3	Household 3	H1 = invalidated H2 = Invalidated H3 = Validated H4 = invalidated H5 = validated H6 = validated H7 = invalidated H8 = validated
4	Household 4	H1 = validated H2 = Invalidated H3 = Validated H4 = invalidated H5 = validated H6 = Invalidated H7 = validated H8 = validated

5	Household 5	H1 = validated H2 = validated H3 = validated H4 = invalidated H5 = validated H6 = Invalidated H7 = validated H8 = validated
6	Household 6	H1 = validated H2 = Invalidated H3 = validated H4 = validated H5 = invalidated H6 = validated H7 = invalidated H8 = validated
7	Household 7	H1 = invalidated H2 = Invalidated H3 = validated H4 = invalidated H5 = validated H6 = validated H7 = invalidated H8 = validated
8	Household 8	H1 = validated H2 = validated H3 = invalidated H4 = validated H5 = invalidated H6 = validated H7 = invalidated H8 = validated

9	Household 9	H1 = validated H2 = Invalidated H3 = validated H4 = invalidated H5 = validated H6 = validated H7 = invalidated H8 = validated
10	Household 10	H1 = validated H2 = validated H3 = invalidated H4 = invalidated H5 = validated H6 = validated H7 = invalidated H8 = validated
11	Household 11	H1 = validated H2 = invalidated H3 = invalidated H4 = invalidated H5 = validated H6 = validated H7 = invalidated H8 = validated
12	Household 12	H1 = validated H2 = Invalidated H3 = invalidated H4 = validated H5 = validated H6 = invalidated H7 = validated H8 = validated

13	Household 13	H1 = invalidated H2 = validated H3 = invalidated H4 = invalidated H5 = validated H6 = validated H7 = invalidated H8 = validated
14	Household 14	H1 = validated H2 = validated H3 = validated H4 = invalidated H5 = validated H6 = validated H7 = invalidated H8 = invalidated
15	Household 15	H1 = validated H2 = Invalidated H3 = validated H4 = invalidated H5 = invalidated H6 = validated H7 = invalidated H8 = validated

Table 4.1 : Results of system validation survey among households

The table above indicated each validation responses from the households based on several key hypotheses mentioned in the methodology and objectives section of this paper.

From the validation results above, we can conclude the validation criteria as per table below:

Hypothesis	Results		Score	Result Analysis
	Validated	Invalidated		
H1	12	3	80% validated	Majority of households have at least gone to recycling centre
H2	6	9	67% invalidated	Most of recycling centres are nearby households area
H3	8	7	53% vaidated	Majority of households feel they will go again to recycling centres
H4	5	10	67% invalidated	Most of the households never contact or engaged with independent waste collector service
H5	11	4	73% validated	It is found that it is hard or not convenient to find and engage an independent waste collector service
H6	12	3	80% validated	Most of households reuse the oil containers or plastic bags to store scheduled waste

H7	3	12	80% invalidated	It is found that to be give free containers are not necessary to make them store waste since they have other available containers
H8	14	1	93% validated	Households prefer to use mobile applications for collection system

Table 4.2 : Summary of system hypotheses validation

From the summary of hypotheses validation above, more than 80% of households have the awareness of sending their scheduled waste to recycling centres before. However, majority of the households (67%) are still not aware of scheduled waste collection service direct from households. Out of the minority that have used collection services from households, 73% think that it is hard or not convenient to engage the collector service due to unease of communication and unclear procedures. It seems a majority doesn't have any issue with containers to store their scheduled waste with 80% agreeing to it. To conclude the validation, 93% validate that the use of an online collection system would effectively make their booking collection easier as they preferred it over the existing manual method.

4.3 Implementation mechanism

In order to implement the online collection system application to households, the usage of Apple Appstore and Google Playstore platforms will be used to publish the application. The reason to use these online application publications is because both platforms have more than 90% application market utilization among mobile phone users. Most households using these two types of platform framework will be able to download the schedule waste online collection application through the internet. The download will take a few minutes to download and install, and after installation, the user can then run the application in their smartphone. Initially, the user will see the registration and information page. Upon completion of self-registration, the user will be directed to the main user page that will show two main application functions; booking collection date/time and scheduled waste types that will be disposed.

For on-site implementation by hands-on guidance, the first area coverage will be focused on terrace residential areas in Shah Alam. The reason is that this area has medium-high income range residents and mostly are households with kids. Normally for family with kids, the parents tend to cook for their children, and they produce a lot of used cooking oil, e-waste as well as spray cans. Therefore, the application will be the best solution for them to dispose the scheduled waste in proper and systematic way. After the terrace housing area, the implementation will go through high-rise buildings such apartments, condominiums, and flats. The implementation at these buildings will require liaising with building JMB (Joint Management Building) to engage with their residents.

One of the key factors to the successful implementation of the online collection system would be the role of partner-collector and JMB. Partner-collector and JMB would be given task to register their list of house coverage areas under their supervision. Their monthly task would be to monitor each household scheduled waste contribution as well as collectively storing these wastes before being collected by the approved DOE contractors. It is their responsibility to weigh the scheduled waste and record it into the online system, as well as to ensure those households that have given the waste to be fairly rewarded. The implementation of online collection system will go through the Beach-head implementation strategy as per below diagram:

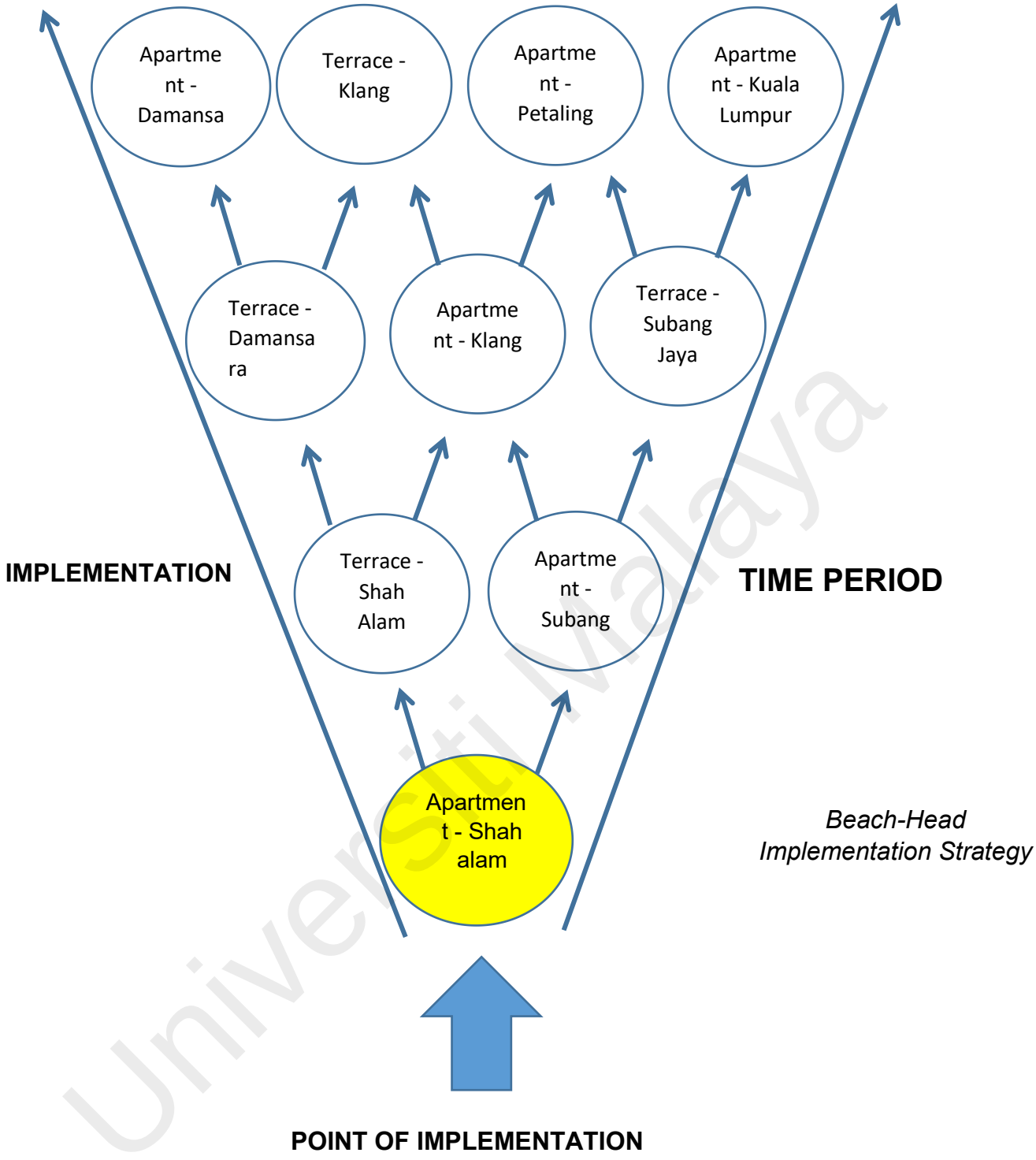

Figure 4.2 : Implementation mechanism using Beach-head Strategy

From the diagram above, the implementation strategy will be through block-by-block in Beach-head method. The first starter would be for all apartments in Shah Alam. Then followed by roll-out to terrace houses in Shah Alam and apartments in Subang Jaya and so on. It resembles widespread implementation over a continuous time period.

4.4 Possible implementation nationwide

It is possible to implement the system nationwide. The reasons are the system is built on popular mobile phone operating frameworks iOS and Android which is used by almost 90% of Malaysian. Anyone can install the application through their respective mobile phone application-stores. With the majority of areas in Malaysia is already covered by at least 3G cellular spectrum and going into 5G, we can see a lot more people using smartphones and subsequently engaged in mobile application software.

However, implementation of online collection system nationwide will require several phases of implementation due to budget and infrastructure constraint. The implementation factors and planned periods are tabulated below:

No	Factors affecting nationwide implementation	Planned Implementation Period				
		Klang Valley	North Region	South Region	East Region	Sabah & Sarawak
1	Warehouse and operation building construction.	Q2 / 2022	Q2 / 2023	Q4 / 2023	Q2 / 2024	Q4 / 2024
2	Onsite training for partner-collectors.	Q3 / 2022	Q3 / 2023	Q4 / 2023	Q3 / 2024	Q1 / 2025
3	On-site marketing and promotional team and hands-on application awareness activity.	Q3 / 2022	Q3 / 2023	Q1 / 2024	Q3 / 2024	Q1 / 2025
4	New logistics fleet and training to driver collectors.	Q3 / /2022	Q3 / 2023	Q1 / 2024	Q3 / 2024	Q1 / 2025

Table 4.3 : Nationwide implementation key factors and plan period

4.5 Impact assessment

The research would be beneficial for households, communities and the environment. At the households level , the introduction of online scheduled waste collection from households would increase the involvement of households to collect and dispose their scheduled waste at the right place, without going out of the house. There will be reduced disposal of used cooking oil into kitchen sink or drainage systems and a decrease in clogging issues that are common nowadays. Moreover, it instils the habit for the municipal waste to be segregated between non-hazardous and hazardous waste in the future. The better segregation would make better operation process at the landfill and reduce toxic leachate generation which is harmful to the environment. Meanwhile, the segregation practice is also good for incinerator plants since they can run the waste-to-energy process more efficiently. This creates more sustainable green energy to power up more households in the future.

At the community level, they would benefit with more jobs provided via gig partner-collector jobs. They earn income by collecting scheduled waste from house-to-house, and the payment calculated by quantity of waste in kilograms. More jobs and income mean more households can have a better and decent lifestyle.

The good news is the environment would benefit most from this research. More scheduled waste will not be thrown freely into the environment, and a lot of these waste will be treated and transformed into new product though the continuous research around the world lab-house. The end target is clear, to achieve at least 70-80% scheduled waste generated from households collected by 2030. It is our responsibility that every item that we use can be reused and sustainable.

Impact Assessment Factors	Levels					Score	
	1	2	3	4	5	B	A
Disposal of used cooking oil	Collected by DOE contractors	Collected by freelance collector	Throw into kitchen sink	Throw into drainage	Into the rivers	4	1
Disposal of e-waste & other scheduled waste	Collected by DOE contractors	Collected by freelance collector	Mix together with municipal waste	Throw into drainage	Into the rivers	3	1
Cleanliness of households	Clean and tidy	Almost clean	Most area clean	Partially clean	Messy and really need improvement	4	2
Collection of scheduled waste process	Seamless process using app	Book using website	Booking by whatsapp	Booking collection using call	Very hustle and wasting time (manual method)	4	1
Environmental impact	Completely no disposal into environment	Very less disposal into environment	Partially dispose into environment	Majority throw into environment	Fully dispose into open environment	4	2

Rating:
1 - (Great)
5 - (Worst)

Score abbreviation:
B - (Before)
A - (After)

Table 4.4 : Impact Assessment after online system implementation

From the table above, through the implementation of online scheduled waste collection system most of the scheduled waste will be collected by approved DOE collectors compared to the common way of disposing it into the environment. Cleaner households are expected due to easy booking of collection service. The environmental impact will be visible over time due to rising awareness of online system collection and lesser people dispose their scheduled waste into the environment.

4.6 Illustration of online system mobile application

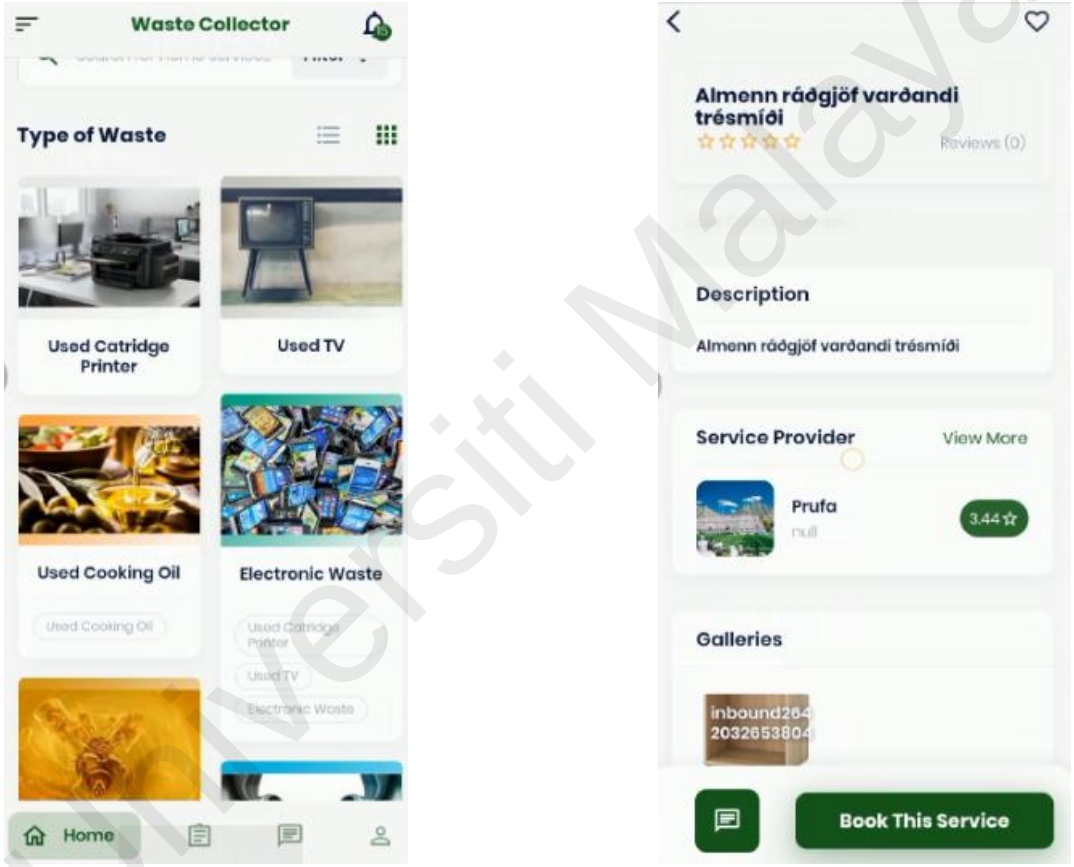

Figure 4.3 : Illustration of online collection app user interface (households)

As per the diagram above, the online system user interface has been designed with simple flow as the main criteria. Households prefer easy to understand interface therefore on the application main page (left picture), it will show the type of scheduled waste that the households want to send. Every type of scheduled waste will be givena picture to let the users know what it is. Then upon clicking the waste type, it will go to the booking order page (right picture) which details the collector's

information and date/time of the collection service required. Users will click the ‘Book this service’ to confirm their online booking.

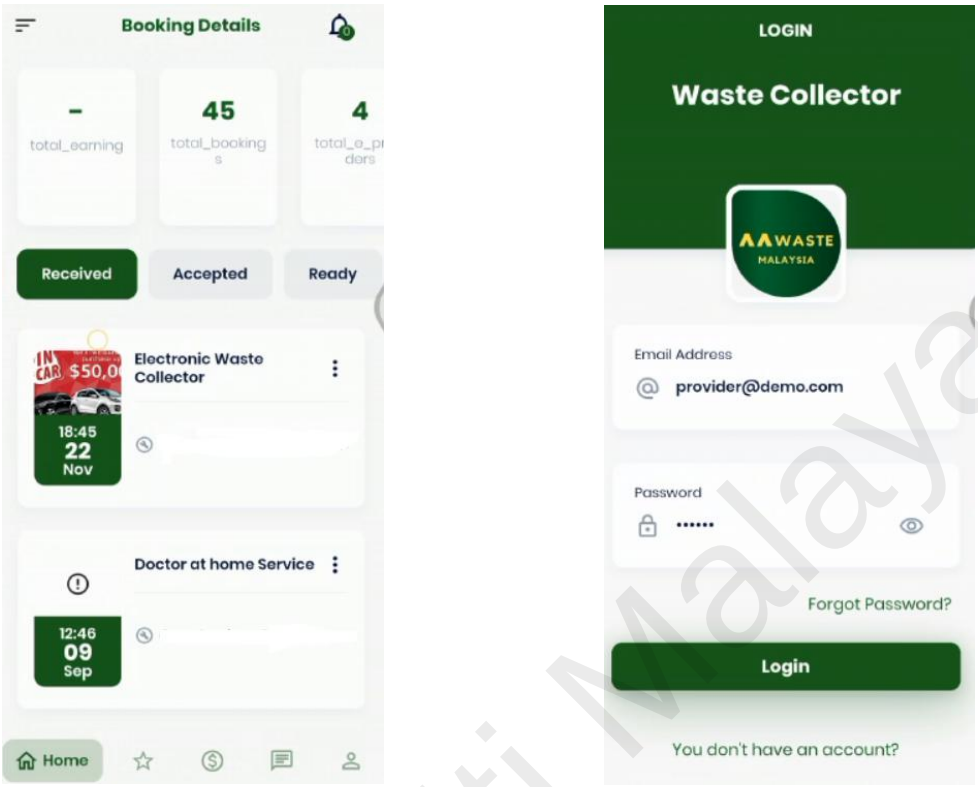

Figure 4.4 : Illustration of online collection application user interface (partner-collector)

In the above diagram for collector’s user interface system, it shows a simple and easy to understand flow. Collectors will be shown their future and current booking service (left picture), details of the household information and summary of their previous collection service. On the right picture, it shows each collector’s own account to login into the system. Every collector will go through a registration check-up before being approved as scheduled waste collectors because these data will be send to the DOE for references.

CHAPTER 5 :
CONCLUSION AND RECOMMENDATION FOR FUTURE WORK

5.1 Conclusion of the study

The development of an online scheduled waste collection system has been the main gap that has plagued households for many years. Many of the scheduled waste generated from households have been disposed into sinks and drainage systems for many years, which have polluted the environment in the long term. The fault is not merely on their shoulders alone, as there is no clear or proper guidance for them to dispose the scheduled waste at the right channel. As the year passed 2021, it is definitely a must for this system to be implemented as soon as possible. Started locally and subsequently nationwide, there is a possibility for this solution to be implemented in other countries especially in South East Asia region.

To fulfil the paper's objectives, many issues and problems related to scheduled waste collection from households have been identified. One of the key reasons is lack of awareness among households on the effect of scheduled waste disposal to the environment. Continuous awareness campaigns are compulsory to educate households of the harmful effect of illegal dumping of scheduled waste at the wrong place. Millions of kilograms of scheduled waste could be saved and treated every year if proper collection systems are implemented.

Proper system flow and user interface of the online collection system has been designed and illustrated to give users the awareness and idea on how the online system would look like. Analysis on validation of the system has been done with 93% of households validate the usage of online scheduled waste collection system since it is more user-friendly and easier to book compared to existing methods. At least 80% of households have at least sent their scheduled waste to recycling centres which shows that majority of households have the awareness to recycle waste. However, the majority of households did not know the service of scheduled waste collection direct from households and at least 73% of them feels that it is difficult to engage the booking service due to unclear procedures and ineffective communications. The implementation of the system gives greater overall rating of environmental impact compared to before the system's implementation.

5.2 Recommendations for future work

Since the world is heading into IR 4.0 and IoT (Internet of Things) infrastructure, we expect more technology will shift into the metaverse and application-command technologies that embraced the use of AI (artificial intelligence). A probable recommendation would include these upgrades:

i) Usage of on-screen online system booking through the smart TV application

ii) Voice-command system that incorporates smart wallet function and thumbprint approval feature.

iii) Metaverse booking system using Ai logistics solution that embraced location function through AI GPS coding function.

iv) Research on automated warehouse control using ceiling RFID/NFC scanning technology.

v) To study the feasibility of AI algorithms to determine oil viscosity by visual scanning using LIDAR technology.

vi) Usage of robotic machines in handling myriad of scheduled waste containers processed at the storing area.

vii) Development of special scheduled waste vending machine with an automatic online payment system.

viii) Drone-based collection system based on AI location service.

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