QUANTIFYING WASTE REDUCTION AND REVENUE SAVED BASED FROM CONVERTING FOOD WASTE TO LIQUID COMPOST

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ABSTRACT

With escalating environmental issues, the need for a sustainable environment is becoming more necessary. In line with that, implementation of circular economy may be a good start towards becoming sustainable. A circular economy is an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life. Majlis Bandaraya Petaling Jaya set up a Smart Waste Solution Lab at SS2 to make use circular economy in managing food waste. The aim of this study is to quantify waste reduction and revenue saved based from converting food waste to liquid compost. The objectives also include assessing public awareness on the importance of recycling household waste and hawker's awareness on the importance of proper food waste management. The method involved were by distributing questionnaires to the public, hawkers and interviews were carried out with MBPJ operators at Smart Waste Solution Lab SS2 Petaling Jaya. The areas covered in the questionnaires and interviews were awareness on waste management, awareness on recycling activities, daily waste production, food waste handling, composting process, charges for landfilling process, operating cost and revenue information for composting process, energy and water consumption. The timeline for data collection was set for a period of six months that is from January to June 2018. At the end of sixth month, the results showed that a revenue was generated as a result of diverting food waste from landfill and reducing the number of dump truck trips to landfill site. This resulted in a saving approximately RM 10848.71. The revenue estimated for a year is RM 21697.42. Hence this savings could be use to start up other smart waste facility to encourage the implementation of circular economy throughout the nation. For public questionnaires, the results showed that more than 50% of respondents separate their food waste however awareness on composting food waste are still very low as 90% of them send their food waste to landfill. For hawker's questionnaires, most of the food waste are coming from plate waste of customers and customers behavior whereas for morning market food waste are due to lack of adequate storage area. In the end of the questionnaires, most of the respondent agreed to contribute in composting food waste to liquid compost if incentive is given. With the savings achieved, MBPJ can demonstrate to other local city councils to duplicate this initiative as it not only saves money but most importantly saves the environment for the future.

ABSTRAK

Dengan isu-isu alam sekitar yang semakin meningkat, keperluan untuk persekitaran yang mampan semakin diperlukan. Sejajar dengan itu, pelaksanaan ekonomi pekeliling mungkin menjadi permulaan yang baik ke arah menjadi mampan. Satu ekonomi pekeliling adalah alternatif kepada ekonomi linear tradisional (membuat, menggunakan, melupuskan) di mana kita menyimpan sumber yang digunakan selama mungkin, mengeluarkan nilai maksimum dari mereka semasa digunakan, kemudian pulih dan regenerasi produk dan bahan di hujung setiap hayat perkhidmatan. Majlis Bandaraya Petaling Jaya menubuhkan Makmal Penyelesaian Sisa Pintar di SS2 untuk menggunakan ekonomi pekeliling dalam menguruskan sisa makanan. Tujuan kajian ini adalah untuk mengkuantifikasi pengurangan sampah dan pendapatan yang disimpan berdasarkan penukaran sisa makanan kepada kompos cair. Objektifnya juga termasuk menilai kesedaran orang ramai tentang pentingnya kitar semula sisa isi rumah dan kesedaran penjaja mengenai kepentingan pengurusan sisa makanan yang betul. Kaedah yang terlibat adalah dengan menyebarkan soal selidik kepada orang ramai, penjaja dan temubual telah dijalankan dengan pengendali MBPJ di Lab Smart Solution Lab SS2 Petaling Jaya. Bidang yang diliputi dalam soal selidik dan wawancara adalah kesedaran mengenai pengurusan sisa, kesedaran mengenai aktiviti kitar semula, pengeluaran sisa harian, pengendalian sisa makanan, proses pengkomposan, caj untuk proses penapisan, biaya operasi dan maklumat hasil untuk proses pengkomposan, penggunaan tenaga dan air. Tempoh masa untuk pengumpulan data ditetapkan untuk tempoh enam bulan iaitu dari Januari hingga Jun 2018. Pada penghujung bulan keenam, keputusan menunjukkan bahawa hasil dijana akibat mengalihkan sisa makanan dari tapak pelupusan sampingan dan mengurangkan bilangan perjalanan trak dump ke tapak pelupusan sampah. Ini menghasilkan penjimatan lebih kurang RM 10848.71. Pendapatan yang dianggarkan selama setahun ialah RM 21697.42. Oleh itu penjimatan ini boleh digunakan untuk memulakan kemudahan sisa pintar yang lain untuk menggalakkan pelaksanaan ekonomi pekeliling di seluruh negara. Untuk soal selidik awam, hasilnya menunjukkan bahawa lebih daripada 50% responden memisahkan sisa makanan mereka namun kesedaran mengenai kompos sisa makanan masih sangat rendah kerana 90% dari mereka menghantar sisa makanan mereka ke tapak pelupusan. Untuk soal selidik hawker, sebahagian besar sisa makanan datang dari sisa-sisa plat pelanggan dan tingkah laku pelanggan sedangkan untuk pasaran pagi sisa makanan

adalah disebabkan oleh kurangnya tempat penyimpanan yang mencukupi. Pada akhir soal selidik, kebanyakan responden bersetuju untuk menyumbang dalam pengkompaunan sisa makanan kepada kompos cecair jika insentif diberikan. Dengan simpanan yang dicapai, MBPJ dapat menunjukkan kepada majlis-majlis bandar tempatan yang lain untuk menduplikasi inisiatif ini kerana ia bukan sahaja menjimatkan wang tetapi yang paling penting menjimatkan persekitaran untuk generasi masa depan

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LIST OF SYMBOLS AND ABBREVIATIONS

MBPJ	: Majlis Bandaraya Petaling Jaya
AD	: Anaerobic Digestion
SDG	: Sustainable Development Goals
BAU	: Business as Usual
MSW	: Municipal Solid Waste
LCA	: Life Cycle Analysis
ZWS	: Zero Waste Campaign
SPSS	: Statistical Package for the Social Sciences

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The purpose of this chapter is to give a brief understanding on the title "Quantifying Waste Reduction and Revenue Saved Based From Converting Food Waste to Liquid Compost". In this chapter, the project background, problem statement that arise from this topic, the main objectives, scope and significance of the study are discussed.

1.2 PROJECT BACKGROUND

Globally, about 1/3 of the total amount of food produced in the world never reaches our plates that is equivalent to $1 trillion dollars. Meanwhile, just a quarter of this is enough to feed 780 million hungry people. Worst still, if food waste were a country, it would be the world's third largest emitter of greenhouse gases.

Majlis Bandaraya Petaling Jaya (MBPJ) are taking efforts to convert all these food waste into useful substance such as liquid compost which could then be used as a soil fertiliser. Currently, MBPJ are taking efforts to turn food waste at SS2 market into compost. Green food waste such as discarded vegetables from the markets are turned into liquid fertiliser. The SS2 morning market in Petaling Jaya was selected to take part in a food waste composting project called A Living Lab. Set up by the Petaling Jaya City

Council (MBPJ) to tackle the food waste problem, the project is collaboration with a private sector.

Beginning March, MBPJ and CH Green Tech Sdn Bhd have been educating market traders on the do's and don'ts of composting besides carrying out the composting process. The main phase of the project was to ensure the composting machines were set up and operational for at least two years. Once the project is stable, the council may manage it on its own.

The aim of the project is to keep running so that the public can see and learn about food composting. The results of the project such as enzymes will be sold to the public and the sales of the composts products will be used to cover the operational cost of the project. Currently, this project is a close-loop concept and is opted for A Living Lab. Close-loop concept is whereby food waste is returned to nature as fertilizers and nothing from the composting process goes to waste.

The challenge is to ensure food waste is free from rubbish such as plastic and glass. The composting process begins with the collection of organic food waste, weighed, shredded into small pieces and fed into the composting machine. It takes between 15 and 30 days for the waste to turn into enzymes depending on the food waste size and structure. The long-term aim is for the biogas gathered from the composting process be used to generate electricity for the entire composting project.

Here items such as dry and liquid compost, liquid fertilizer, fruits and vegetables and items produced through the project will be sold. A Living Lab can be replicated in other locations on a decentralized basis where cost savings from logistics, tipping fees to landfills, low carbon emissions, and 3R, are vital. The food waste can be creatively

transformed into valuable resources and the hope is all councils will embark on such effort in the country.

With the implementation of Smart Waste Solution Lab at SS2, more waste can be recycled resulting in less waste being sent to landfill. A close loop circular economy system is being implied at this facility. What happens here is food waste is collected from three different locations and undergoes source separation. Next, the food waste are place inside large containments and undergoes anaerobic digestion process for approximately 20-25 days depending on the type of food waste being digested. Finally, this food waste is converted into liquid compost where it act as fertilizers and can be directly used for landscaping or farming activities. As part of this process, biogas is also produced where it can be used for heating or cooking. When fully functional, it is estimated that nearly half of the waste can reduced with the introduction of this initiative.

There is also an organic farm being set up at the empty space beside the facility. Various vegetables and fruits are grown phase by phase. Some of the vegetables and fruits are rock melon, chillies, brinjals and lady fingers. Currently vegetable scraps and food waste are used and then ending up with vegetables that we sell to the public, and fertiliser that people can use to grow their own vegetables and plants at home

Previous crops include rock melon and chilli, while their current batch includes ladies finger, kailan and brinjal. About 500 grams of kailan can be harvested per poly bag, so there over 100 kilo potential yield growing here now," explains Amir Hamzah from UPM who supervises the fertigation system. His mission is to find the best solutions in utilizing the fertiliser.

1.3 PROBLEM STATEMENT

One of the major problems in Malaysia is the management of food waste. Increasing population will result in the increase in amount of waste. However, food waste has seen an enormous growth based on the past few years. Nearly half of municipal solid waste comprises of food waste. This is an alarming issue if not well managed in the early stage. Even the CEO of SWCorp stated that most of the waste are avoidable waste.

Wastage of food waste may be due to improper management or behavioral habits among consumers. This is very common when visiting restaurant where nearly half of the food are wasted. United Nation of Agricultural Organization estimates nearly 1.3 billion tonnes of food are being wasted. Imagine this food can feed the homeless and poor society. Indeed, action need to be taken to prevent worsening the issue.

Based on research done by SWCorp, food waste increase significantly during festivals. None is aware that more waste being sent to landfill will result in a more negative impact to the environment. This is because, when this waste decompose it will release greenhouse gas to the environment. It can be clearly seen that the awareness among the community is still very low.

Bad waste management practices can result in land and air pollution and can cause respiratory problems and other adverse health effects as contaminants are absorbed from the lungs into other parts of the body. Moreover, dumping all waste directly to landfills is also a loss of resources especially non renewable sources. With all these issues, a case study is going to be conducted at Smart Waste Solution Lab, PJ which will meet the stated objectives below. This facility is currently collecting food waste from the nearby hawker

stalls and hence converting the food waste into liquid compost resulting in a close loop cycle.

1.4 OBJECTIVE

1. To assess public awareness on the importance of recycling household waste focusing on food waste
2. To investigate hawker's awareness on the importance of proper food waste management.
3. To quantify how much money can be saved based on the case study

1.5 PROJECT SCOPE

As overall, this project will only be concentrating on the waste management. With regard to waste management, the scope will directly focusing especially on food waste rather than other wastes such as industrial or manufacturing waste. Besides that, this project will currently focus on the efforts and initiatives being carried out by MBPJ around Petaling Jaya (PJ) SS2.

1.6 SIGNIFICANCE OF STUDY

By carrying out this project, a better understanding and a more transparent framework can be portrayed. Not only it will encourage local authorities, but people habits are also a key role in reduction of waste. Below points out the significance of this project.

Reducing waste will result benefit in the improvement of the environment, economy and a positive impact towards the betterment of nation.

- Environment

- Economy
- Betterment of nation

Environmental

- As the growth of population is increasing, there are fewer place and empty lands to carry out landfill. By reducing waste, there are lesser needs to create landfill sites.
- Reducing waste result in lesser material consumption which indirectly result in lesser energy consumption

Economy

- Economic growth is very obvious because since less waste is being sent to landfill, less tipping fees and transportation fees is required
- Savings can be achieved by recycling materials
- More green growth can be achieved in industries

Betterment of Nation

- Promote awareness on waste management to younger children from small
- Increase the image of the country because of clean environment
- Attract more tourist to the country
- Reduce the risk of spreading of dangerous disease

By providing facts and figures such as amount of waste can be reduced and amount of money can be saved, MBPJ efforts can act as a role model for other local authorities to visualize and hence carry out initiatives at their respective locations.

1.7 THESIS OUTLINE

Firstly in Chapter 1 is a brief understanding about the overall title which is "Quantifying Waste Reduction and Revenue Saved Based from Converting Food Waste to Liquid Compost". The topics discussed are project background, problem statement, the objectives, scope and significance of the study.

In Chapter 2, a detail literature review will be done on circular economy. This issue will be addressed on a global level followed by a narrower scope such as addressing Nation's issue. The economic and environmental benefits of circular economy, importance of proper waste management system and countries with good waste management system will also be discussed.

Next, in Chapter 3, the methodology will be discussed focusing on Majlis Bandaraya Petaling Jaya (MBPJ) efforts and initiatives to convert food waste to liquid compost. In this chapter, the method of data will be discussed and deliberated.

In Chapter 4, result and discussion will be focused on the amount of waste can be recycled in weekly and monthly basis. With the amount of waste recycled, amount of savings that can be achieved will also be calculated. Furthermore, quantification will also focus on amount of waste can be converted to liquid compost and total revenue can be achieved by the sales of liquid compost.

Finally, in Chapter 5 a summary of obtained results will be done and hence recommendations will be suggested for future improvements.

CHAPTER 2

INTRODUCTION

2.1 INTRODUCTION

Circular economy is a one close loop process beginning from the product being used or manufactured and ending up as a recyclable material instead of being dumped in landfills. The main purpose is to reduce waste being generated and at the same to strive towards achieving sustainability development. In this chapter, circular economy, advantages and environmental benefits of adapting circular economy, waste management and Zero Waste in University Malaya and finally countries with good waste management system will be elucidated.

2.2 SUSTAINABLE DEVELOPMENT

The Sustainable Development Goals (SDGs), otherwise known as the Global Goals, are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. These 17 Goals build on the successes of the Millennium Development Goals, while including new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, among other priorities(Organization, 2015). The goals are interconnected – often the key to success on one will involve tackling issues more commonly associated with another. The SDGs work

in the spirit of partnership and pragmatism to make the right choices now to improve life, in a sustainable way, for future generations (Robinson, 2004). They provide clear guidelines and targets for all countries to adopt in accordance with their own priorities and the environmental challenges of the world at large. The SDGs are an inclusive agenda. They tackle the root causes of poverty and unite us together to make a positive change for both people and planet.

Responsible Consumption and Production (Goal 12) is known throughout the world and people around the world practices the act of doing so (Kates, Parris, & Leiserowitz, 2005). Responsible Consumption and Production is mostly about using natural resources efficiently, reducing food losses and waste generation, manage the wastage of chemicals. Malaysia is still lagging behind in sustainable waste management practices, particularly in recycling. In 2015, Malaysia's recycling rate is still 10.5% compared to other developed countries who have reached to a rate of more than 40%. The authorities stated that even though the citizens are aware of the importance but their response has still not reached the expected level. Malaysians produce approximately 30,000 tonnes of waste every day but only 5% are recycled. The government has set a target for the Malaysia's recycling rate of 20% by 2020 (Manaf, Samah, & Zukki, 2009).

Goal 12: Ensure sustainable consumption and production patterns

Sustainable consumption and production is about promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for all (Omer, 2008). Its implementation helps to achieve overall development plans, reduce future economic, environmental and social costs, strengthen economic competitiveness and reduce poverty. Sustainable consumption

and production aims at "doing more and better with less," increasing net welfare gains from economic activities by reducing resource use, degradation and pollution along the whole lifecycle, while increasing quality of life. It involves different stakeholders, including business, consumers, policy makers, researchers, scientists, retailers, media, and development cooperation agencies, among others. It also requires a systemic approach and cooperation among actors operating in the supply chain, from producer to final consumer. It involves engaging consumers through awareness-raising and education on sustainable consumption and lifestyles, providing consumers with adequate information through standards and labels and engaging in sustainable public procurement, among others.

2.3 CIRCULAR ECONOMY

A circular economy is an economic system where products and services are traded in closed loops or 'cycles'. The closed-loop or circular economy model has emerged from the discipline of industrial ecology (also known as industrial symbiosis) in which the functioning of ecosystems has been used as an example for industrial processes and systems. A circular economy is described as an economy which is regenerative by outline, with the mean to hold however much incentive as could reasonably be expected of items, parts and materials. This implies the point ought to be to make a framework that takes into consideration the long life, ideal reuse, renovation, remanufacturing and reusing of items and materials (Kraaijenhagen, van Oppen, & Bocken, 2016; Morlet et al., 2016). In a circular economy material cycles are shut by following the case of standard environments. Toxic substances are killed, there is no waste since every lingering stream are profitable as asset, items are reclaimed after use for repair and remanufacturing keeping in mind the end goal to reuse the items a second, third or fourth time, and leftover streams are isolated in an organic and specialized cycle (MacArthur, 2013a). A circular economy is one that is

restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles. This new economic model seeks to ultimately decouple global economic development from finite resource consumption. A circular economy addresses mounting resource-related challenges for business and economies, and could generate growth, create jobs, and reduce environmental impacts, including carbon emissions. As the call for a new economic model based on systems-thinking grows louder, an unprecedented favorable alignment of technological and social factors today can enable the transition to a circular economy. A circular economy is an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life.

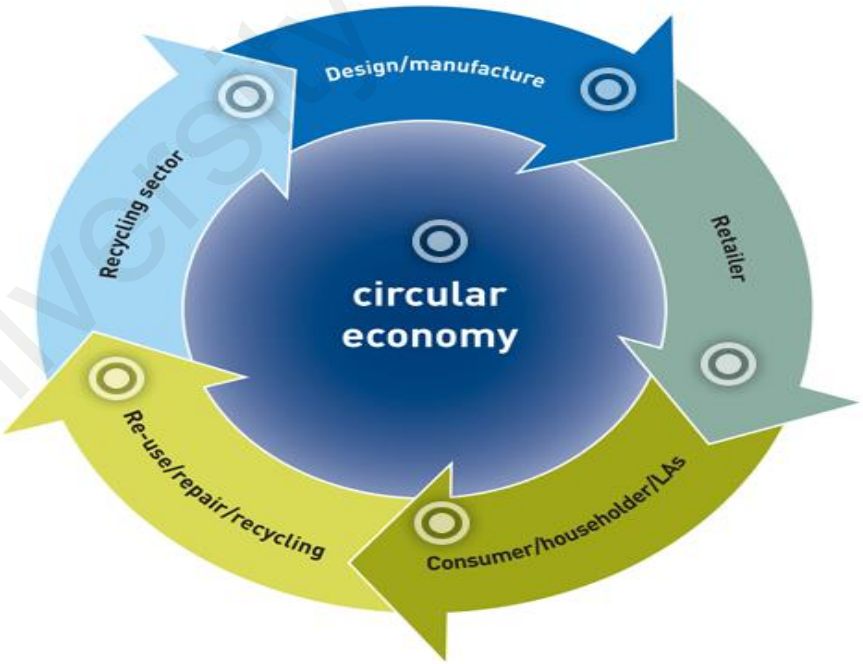

Figure 2.1 : Circular Economy

Source: The Waste and Resources Action Programme (2016)

As well as creating new opportunities for growth, a more circular economy will:

- reduce waste
- drive greater resource productivity
- deliver a more competitive UK economy.
- position the UK to better address emerging resource security/scarcity issues in the future.
- help reduce the environmental impacts of our production and consumption in both the UK and abroad.

2.3.1 Difference between Circular economy and Linear Economy

Circular economy and linear economy both have a different approach in the step and implementation process of the plan. The main difference as an overview is to investigate items that can be reused to be avoided being sent to the landfill.

Step Plan

The step plans of both linear economy and circular economy have different approach. Linear economy works on the principle of manufacturing something from raw material, using it until it cannot be used anymore and finally be disposed as waste. Circular economy uses a slightly different approach that is reduce, reuse and recycle (3R) concept. During manufacturing, it identifies the most minimal resources and material required. Not only that, it also identifies any recyclable materials are available to make or manufacture the specific product. Once it cannot be used anymore, instead of being thrown away as waste, materials are salvaged in order to gain maximum benefit so that these materials has another purpose and not being wasted as waste.

Sustainability through eco-effectiveness or eco-efficiency

Linear economy focuses more on eco efficiency while circular economy focuses more on eco-effectivity. There is a slight difference between eco-efficiency and eco-effectivity. Eco-efficiency is doing something that can gain economic value and at the same time reduce the environmental impact. Whereas, eco-effectivity is while reducing the negative impact to the environment, focus is put on how to create a positive impact to the environment (Braungart, McDonough, & Bollinger, 2007). This way is more effective as we are in control of our doing to improve the environment.

Quality of reuse practices

What plays a more significant role between linear and circular economy is the quality of reusing the material. In linear economy, reusing is practiced but only for small and not very important purpose. In other words, the reusing process doesn't give much value added properties (Bocken, Short, Rana, & Evans, 2014; MacArthur, 2014). Whereas, in circular economy, items are reused for a more important purpose and gives a high value in term of economic savings.

100% circular economy

To maintain a 100% circular economy is very difficult as it depends on many factors (Andersen, 2007). The best practice is to make it as circular as possible. When materials are extracted to be reused, the quality often drops and it always require further input materials to be improvised. Although it cannot be at 100%, it does not mean linear economy will be forever but the mindset could be changed to achieve circular economy. This can be done by improving the current economy to circular (MacArthur, 2013a).

Examples are, promote recycling. This will eventually reduce raw material intake and increase the efficiency of circular economy (MacArthur, 2014).

2.3.2 Circulation of Materials in a Circular Economy

In a circular economy materials circulate in material cycles. These cycles operate according to several conditions.

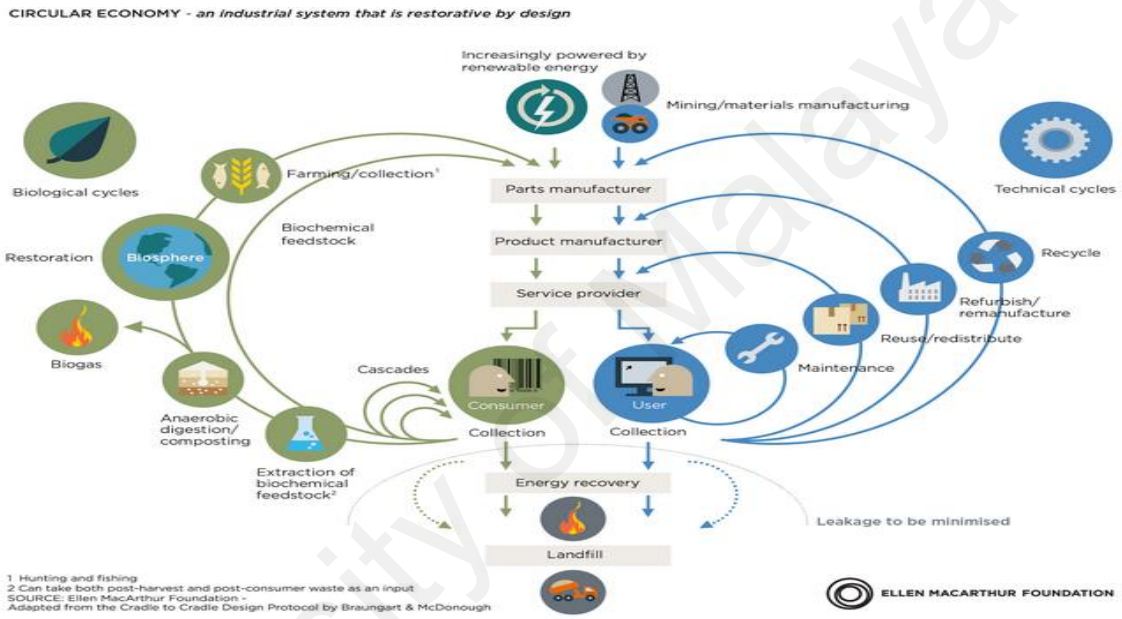

Figure 2.2 : The Butterfly Diagram

Source: Ellen Mac Arthur Foundation

Bio-cycle & techno-cycle

Organic materials such as food and technical materials such as plastic have different recycling process. Therefore, it is important to have a proper segregation facility to separate these two items. Technical materials including fuels cannot be renewed. Hence, its handling and recycling process need to manage properly. Organic materials can be recycled naturally through the bio-cycle. The bio-cycle just need proper conducive environment including optimum temperature and oxygen to function properly. Through this process, all organic materials are renewable.

Cascades

Cascading is a process of reusing a certain product or material for a different purpose based on its initial intended purpose of use. This process of cascading often takes place in bio recycling. When a certain product can longer work at 100%, it can then undergo cascading process as so it can be used for another function instead of being thrown as waste. Cascading in not the same as reusing because the initial function of the product has changed and there may be some addition or improvement be made (MacArthur, 2013a). For an example, an old shirt can be used as a cloth for cleaning but in cascading the old cloth may be modified to be used as table cloth.

Prolonged cycles

The main aim in both bio-cycle and techno-cycle is to prolong its cycle to ensure it does not end up in the landfill soon. The longer the cycle, the more saving can be achieved in terms of economic value. Prolonging the cycle will ensure less items are discarded as waste and sent to landfill. This can be done by ensuring the product undergoes several cycles of functionality until it cannot be used anymore. This is to maximize the value of the product fully.

2.3.3 Boundary Conditions for a Circular Economy

1. Conservation of natural capital

A circular economy is only successful when it decreases climate change and depletion of resources. Instead, it should have a positive impact on our ecosystem. This means that natural capital, should be maintained and strengthened by using the available

non-renewable resources with care, and balancing the use of renewable raw materials within the limits of what our ecosystem can handle.

This can be realized by:

- Dematerialisation: Replace products, when possible, with a service (product service systems).
- Smart materials: Choose materials that last and processes that consume little and renewable energy.
- Facilitate ecosystems: Ecosystems are balanced by extracting and introducing nutrients ate the right place and the right time.

2. Optimization of cycles

In order to maximize the yield of the circular economy, it is important to optimize the completion of the cycles. This means that products and components are used as often and as long as possible, that they are designed to last, to be repairable, and that they are easy to disassemble for recycling.

In addition, products are designed to provide more functionality with less material to more people. This means:

- Those products are designed with less material (dematerialisation); to perform multiple functions (multifunctionality); or are replaced by a service.
- Sharing-platforms where products are interchanged and borrowed. That it is possible to make several people use the same product. This is possible through business models where products are used temporarily and are taken back by the retailer, via lease models, product service systems, and rental services.

3. Focus on system effectiveness

Within a circular economy, the focus should be put on the effectiveness of the system as a whole. The circular economy will only be able to live up to its potential when the complete system changes, by means of a transition. When the whole economy, not just the frontrunners, functions as a circular economy, the benefits will be fully realized. To facilitate this, the harm of vital elements of our system, such as education, food, mobility, housing and health care, should be avoided where possible. This can be done by monitoring indicators such as land use, air and water quality, contamination by toxic substances and (noise) nuisance.

This results in a need for responsible decision-making, where the following elements are taken into account:

- The connections between different parts of the system
- Long-term consequences
- Effects of each step in the life cycle of products
- Impact on environmental, social and economic value

2.3.4 Disadvantages of Current Linear Economy

Linear economy although is easier to manage brings together more negative impacts to it. It can be clearly seen with the increase in pollution rate, shortage of raw materials and increase in price of raw materials. Linear economy does not give a solution to these problems but instead piles up to these problems. With the increasing number of population in the world, demand of raw materials is also increasing proportional. Hence, it is the best time to switch to circular economy.

Supply risks

If we continue to depend on linear economy, there will be a supply risk in the near coming. Supply depends on many factors such as raw material, demand and pricing. It can be monopolized by large suppliers causing fluctuations of pricing. At the end of the day, it will affect consumers as consumers are last in the supply chain.

Price volatility

It is common to see price increasing at a fast rate but it is very rare to see price of items dropping. This is because, lack of stability in market demand and supply causes the price to increase. Risk of doing investment is high too as price cannot be predicted due to its volatility. In the end, as time passes, raw material prices will increase (Lee, Preston, Kooroshy, Bailey, & Lahn, 2012).

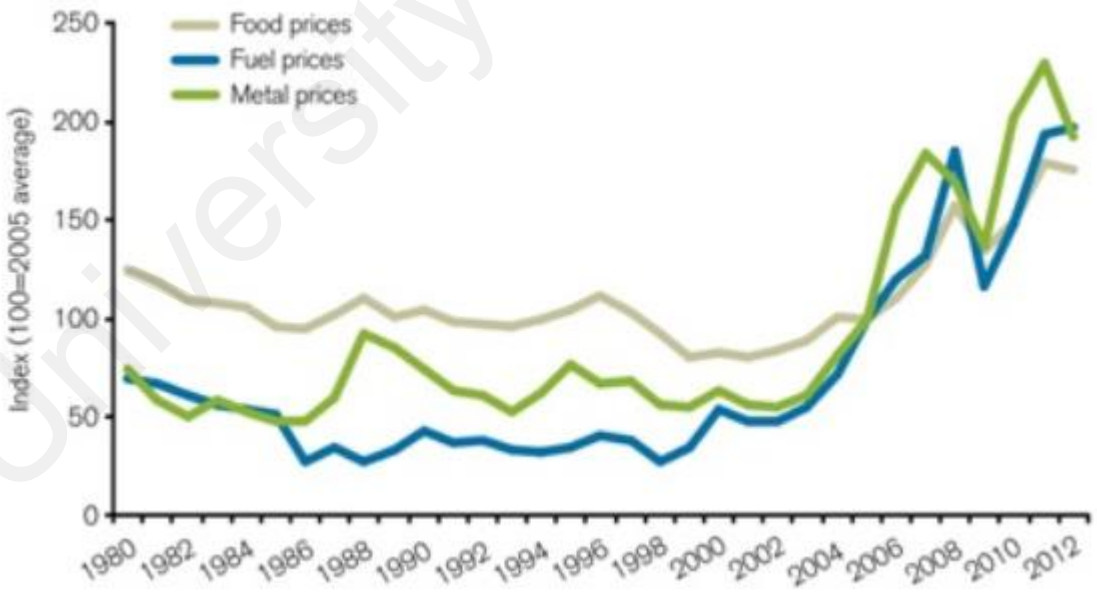

Figure 2.3 : Fluctuation in Commodity Prices

Source: Chatham House based on IMF (2012)

Critical materials

Countries like Netherlands have proven they are highly dependent on critical materials (Delahaye & Zult, 2013). This means, they are unable predict the prices of raw materials due to fluctuations and are less competitive (Lacy et al., 2014). Common industries that are dependent to critical materials are electrical and electronics and semiconductor industries.

Interconnectedness

There are many interconnectedness between one item and another item. For an example, when raw crude oil and fuel price increases, there will be definite impact on prices of food as well. This is because, suppliers will claim there has been an increase in transportation fee. Hence, any industry that are directly interconnected with a lot of raw products will have an increase in prices of goods(Lee et al., 2012; MacArthur, 2013a).

Increasing material demand

Research has already showing that population growth can hit up to 10 billion by the year 2030. Because of population growth, there is also going to be an increase in demand of materials. To ensure sustainability, this resources need to be well managed. The most common way is to reduce the depletion of resources by increasing material pricing (George, Schillebeeckx, & Liak, 2015; Jackson & Senker, 2011; MacArthur, 2013b; Use, 2011)

Degradation of ecosystems

Based on the concept of linear economy, most of the items after being used will end up in landfill site. This mean, more waste will be piling. Wastes that are well managed such as undergone incineration or buried may not give any significant impact to the environment

but waste that are just left as a garbage dump will cause significant impact. This will lead to excessive material wastage that may not have any function (MacArthur, 2013a).

Decreasing lifetime of products

Lifecycle of products are no longer the same back in the 19th century. Those days, items could last for years but nowadays it could not last very long leading to shorter life cycle of products. With new technologies and rapid enhancement may also be a driving factor why consumers often want to buy a new product. This is very common especially in the electronics industry relating to mobile phones. This has a created a change in the mindset of suppliers of creating less quality product so that consumers will change their products more often (Bakker, den Hollander, Van Hinte, & Zljlstra, 2014).

Misfit with the need for accountability

Consumers have the power to change the mindset of nation towards practicing circular economy. When a company or industry does not practice sustainable activities, consumers have the rights to not support these industries. They should not buy their products. Politician should also make laws for industries to follow as guidelines (Lacy et al., 2014).

2.3.5 Economic Advantages of Circular Economy

There are many benefits with regard to the implementation of circular economy. This includes more savings in terms of economic value as lest materials are consumed and products have a longer life cycle resulting in fully utilizing its function and values.

Economic growth

An important principle of circular economy is the decoupling of economic growth from resource consumption. Calculations by McKinsey & Co. indicate that in a circular economy the GDP, and therefore economic growth, increases. This is the expected result of a combination of increased revenue from new circular activities, and cheaper production by getting more functionality from materials and other 'inputs'. The effect of this difference in input and output leads to higher valuation of labor, thus increasing income and expenditure per household. This results in a higher GDP.

Substantial resource savings

In theory, the circular economy has the potential to lead to material savings of over 70% when compared with raw material extraction in business-as-usual models (BAU). Taking into account the growth of the world population and especially the middle class, the total demand for materials will still increase, but at a slower pace than without a circular economy. This leads to a lower overall material need in a circular economy than under BAU, with the necessity to consume less and prevent landfill (MacArthur, 2014).This material saving can result in an annual cost saving of $ 630 billion for the sectors of consumer goods with an average longevity (electronics, bicycles), and material savings of 20% in the sectors of products with a short lifespan (packaging, food, clothing) which equates to a cost saving of over $ 700 billion (Morlet et al., 2016). One of the methods for stimulating raw material savings is the pricing of commodities, either by measuring the direct eco-costs of the manufacturer, or by getting a complete understanding of the total cost of the impacts of raw materials.

Employment growth

A large study by The Ellen MacArthur Foundation, SUN, and McKinsey on the effects of the transition to the circular economy on employment, it is concluded that employment will grow as we move to a circular economy. These jobs will be created through

- An increase in spending by lower prices.
- An increase in labour-intensive high quality recycling and repair practices.
- An increase in jobs in the logistics sector by locally taking back products.
- An increase in new businesses through innovation, the service economy and new business models.

Incentives for innovation

Circular economy asks for innovative solutions based on a new way of thinking. Reflecting on circular rather than linear value chains and aiming for optimization for the entire system where an organization is part of, results in new insights, and interdisciplinary collaboration between designers, manufacturers and recyclers and sustainable innovations (Kraaijenhagen et al., 2016).

2.3.6 Environmental Benefits of Circular Economy

The initial target for the circular economy is to have a positive effect on the ecosystem and to counteract the overload and the exploitation of the environment. The circular economy has the potential to result in a reduction in emissions and use of primary raw materials, a optimization of agricultural productivity, and a decrease in negative externalities.

Fewer emissions

By following the principles of circular economy greenhouse gas emissions will be reduced:

- By re-use, dematerialization, and service models, there are fewer (polluting) materials and production processes required to provide adequate service and functionality.
- Energy-efficient and non-toxic materials, manufacturing and recycling processes will be selected.
- The system makes use of renewable energy instead of fossil fuels.
- Residues (including water, gas and solid form) are seen as valuable and are absorbed as much as possible to reuse in the process.

In Europe this may lead to a reduction of 48% carbon dioxide emissions in 2013, or even 83% in 2050(Allwood, 2014).

Land productivity and soil health

The application of the principles of circular economy on the farming system encourages to no longer exploit land and ecosystems but to ensure that important nutrients are returned into the soil. Waste is avoided without sacrificing the productivity of the soil. As a result, the value of the land is growing and the system is more balanced and more resilient. In Europe, a circular approach of our food systems can lead to a decrease of 80% of artificial fertilizer. This restores the natural balance in the soil (Morlet et al., 2016).

Fewer negative side effects

By following the principles of circular economy, minimizing waste and emissions and separating products to pure residues, unsustainable externalities are managed, such as land use, water, air and soil pollution, emission of toxic substances and climate change (Morlet et al., 2016).

2.3.7 Key Elements of Circular Economy

Prioritize Regenerative Resources

Ensure that renewable, reusable, and non-toxic resources are utilized as materials and energy in an efficient way.

Preserve and Extend what's Already Made

For the period of time that resources remain in use, they should be maintained, repaired, and upgraded to maximize their lifespan. When no longer in use, resources should be given a second life through take back strategies when applicable.

Use Waste as Resource

Utilize waste streams as a source of secondary resources and recover waste for reuse and recycling.

Design for the Future

Use the systems perspective during the design process in order to select the right materials, design for appropriate lifetime, and design for extended future use.

Collaborate to Create Joint Value

Increase transparency and create joint value by working collaboratively throughout the supply chain, both internally within organizations and with the public sector.

Rethink the Business Model

Consider opportunities to create greater value and align incentives through business models that build on the interaction between products and services.

Incorporate Digital Technology

Track and optimize resource use and strengthen connections between supply chain actors by using digital, online platforms and technologies that provide insights.

2.4 Waste Management System

Lifestyle of Malaysia is changing in line with the nation's rapid growth of urbanization. More and more population forces more development to cater enough space for everyone. More population means more consumption and definitely more waste being produced. Not only waste from the community is a concern but waste from the industries is also a big concern. Malaysia has been generation nearly over 30,000 tonnes of municipal waste daily (Agamuthu et al., 2009). From this amount, nearly 50% is coming from kitchen waste. In other words, if this problem can be tackled, 50% of the waste can be reduced. This was mainly observed in major cities of Klang Valley.

2.4.1 Methods of Waste Management System

Sanitary Landfill

Sanitary landfill is one of the most common disposal method especially in Malaysia. However, some improvement has been made compared to the earlier days where the waste was dumped and covered with soil. Nowadays, proper methods are done to bury the waste. First, an area is excavated creating space for the waste. At the bottom of the base, sand is normally spread and is covered with several layers of membranes or plastic. This acts a s

barrier to contain any fluid from the waste in being absorbed into the soil. Next, the waste is placed and compacted. Once full, it is again covered by soil and a few layers of membranes. The top surface is then planted with trees to change the environment looks.

Incineration

Incineration is a method of burning ashes into the environment. It is a fast process of disposal compared to sanitary landfill. There are many types of incinerators depending on the type of waste and moisture content. It is normally used by large operators as this method can reduce the volume of waste when the process is completed. The only concern regarding this process is the possible toxic emission released as part of the burning process. Residents living nearby incinerators often raise concerns regarding this issue. Besides, the initial operating cost is also quite high.

Recovery and Recycling

Recovery and recycling process is a common activity done at most landfill site. Here the workers try to discover any valuables than can be recycled. Then these items are either sold or reused for another purpose. This effort result in minimal energy consumption and also reduce the consumption of new raw materials.

Composting

Composting is becoming quite a habit nowadays due to the benefits it delivers. Composting can only be done for organic and biodegradables materials. It can undergo anaerobic digestion or aerobic digestion depending on the condition and environment. Once the composting process is completed, a compost is formed and acts as a fertilizer.

Pyrolysis

Pyrolysis is a method of combusting waste without the presence of oxygen. This can be done by modifying the condition to high pressure where the waste will disintegrate into gas and small particles of solid and liquid.

2.5 Countries with Good Waste Management System

Japan is typical country that adopted principles of prevention of municipal solid waste (MSW) and indorsing recycle, reusing and recapture (Buttol et al., 2007). Various recycling laws were endorsed, including the containers and packaging law, the electric and household applications recycling law, the food recycling law, the automobile recycling act, and the construction material recycling act in the late 1990s and early 2000s (Okuda & Thomson, 2007). Food waste from the commercial sector such as shops and restaurants are burned experiencing private costs. Due to the difficulty in storing food waste at home and collecting it once a week basis, organic waste from households has been excluded as an option for recycling.

2.5.1 Dog and Cat Vending Food Machine

One of the major cities in Turkey called Istanbul has been a habitat for thousands of stray dogs and cats. Some of the residents are open of their presence while some feel there are nuisance to their daily life. Not all may like the presence of stray dogs and cats as some time these animals may dirty their yard. In order to curb this problem and give these animals a better life, a company called Pugedon came up with a great idea to invent the Pugedon Smart Recycling Boxes. This machine tends to recycle bottles for dogs and cats food.

When the company came up with this proposal, there was a mix reaction in the opinions of the neighbourhood. Some were happy with the initiative as it will reduce the roaming of these animals as some residents feel unsafe with their presence. However, some disagree with this initiative, as they feel these animals will make a home near the vending machines causing a negative look the city. Some of the residents voice out their opinions by saying these animals have been part of the city for many years and should be allowed to stay there.

The Government Officials whereas have another suggestion to shift the stray animals to another location. In this location, these animals will be taken care, feed and treated so they will have a better life. An adoption centre will also be opened so that anyone can adopt them if they need them. The environment will also be safe for these animals.

An idea that's a dog's dinner! Company creates vending machine that feeds stray animals in return for people recycling bottles.

- Feral-friendly invention has been introduced in Istanbul city centre
- Inventor Engin Girgin says it kills two birds with one stone
- Every bottle or can inserted releases a portion of food for an animal
- Profit made from recycled bottles covers cost of the pet food
- Vending machine is now being distributed to 20 cities outside Turkey

A Turkish company came up with a brilliant method that could save the environment and also feed stray dogs and cats. It is also an act of noble deed as it saves the environment it also gives stray dogs and cats another purpose to live. This noble act was done by Engin Girgin who created a vending machine to recycle plastic bottles and cans. In return, a small portion of food for dogs and cats will be dispatched. There are a high

number of stray dogs and cats in Istanbul. Hence, instead of allowing them to search in garbage bins and making the environment dirty, this way would allow the stray dogs and cats to be more well behaved and encourage the community to recycle more. Besides, this vending machine is environmental friendly too. It does need any electricity consumption as it is fully powered by solar system.

There is also no any additional charges required for the community to pay. All they need to do is drop their plastic bottles or cans and a portion of food will be dispatched. The inventor of the machine also said, the profit made from recycling the plastic bottles and cans will be used to buy the dogs and cats food. The inventor added that the machine is also able to detect if the bottles are not empty and able to segregate the remaining water in the bottle into a different compartment so that it can be dispatched to be given to the dogs and cats.

Figure 2.4 : Pugedon Smart Recycling Boxes

Source: EarthPorm.com

2.5.2 Germany Plastics and Glass Bottles Machine

In Germany, for every plastic bottle bought, a deposit fee has been incorporated in the total value paid. This deposit can be returned by recycling the bottles into specific recycling machines. If the bottles are thrown into the rubbish bin without recycling, the consumer is not able to get the deposit back. The deposit fee is usually around 25 cents per bottle depending the amount in the bottle. The specific recycling machines are normally available in most supermarket. What consumers need to do is place their used plastic bottles into the machines. The machine will then scan the bar code o the bottle to verify it. Next, the machine will print a digital receipt stating how much money is refunded. The money can be refunded by showing the receipt to the cashier in the supermarket or by deducting the bill from the items purchased in the supermarket.

Deposit Collection System in Germany Promotes Plastic Bottle Recycling

Germany as a nation in the field of green environment, is one of the nations in Europe that do the arrangement of plastic container store accumulation. In Germany's stores, one bottle of mineral water in the volume of 0.5 liter is evaluated at 0.99 euros, which costs more cash compared to other European nations. This is because there are 0.25 euros of value added for the plastic container incorporated into the aggregate cost. Germany began the activity of plastic bottles reusing and refreshment can reusing in the time of 2003, turning into the primary nation to do that in Europe. The directions stipulated that locals need to pay 0.25 euros for each bottle when they purchase water or drink under the volume of 1.5 liter, and just when they restore the containers would they be able to recover the store.

The act of recycling not only depends on one party but it also need a comprehensive support from different parties. The government and the people of the nation should work hand in hand if they would like to achieve a high percentage recycling rate. This is definitely observed in Germany. Besides, every recycling activities done comes with an incentive to promote the culture of recycling. For instance, when the bottles are placed inside the recycling machine, the person will receive the deposit initially paid. It is definitely a win-win situation for both parties. The act of promoting recycling awareness should come from early stage. This is where the government plays its role. One of the initiative done by the government is to promote simple packaging for plastic bottles to the manufacturers. For an example, to remove all labels on plastic bottles packaging so that these items an easily be recycled when they are used. Best be said, other nations should also look into this initiative.

Figure 2.5 : Plastic Bottle Recycling Machine

Source: The UK-German Connection

Tossing bottles and other refreshment bundling in the canister? What a misuse of assets and cash. In a Zero Waste society all refreshment holder would be refilled commonly

before it would be reused into another compartment. Relatively few decades prior drinks were for the most part packaged in refillable compartments with stores. Stores are a whole of cash we give as security for a thing obtained for impermanent utilize, once we give back the thing we get back the cash. In the most recent decades and years, this has changed; the pattern goes towards discard one-way bundling. This is an exceptionally wasteful method for utilizing assets.

There are three different ways to manage drink bundling:

- Refilling (typically with deposit)– bottles/jars are utilized by the client, transported back to the filler (maker), washed, refilled and transported back to the client for utilize. Refillable glass containers can be refilled more than 50 times, refillable PET-restrains to 15 times. The outcome is zero litter, least ecological effect and significant cost reserve funds for the districts.
- One-way store – bottles/jars are utilized by the client just once, the maker can get back the materials or they will go specifically to the reusing organization that will deliver fresh out of the box new containers which at that point should be refilled and transported back to the client. Zero litter however higher natural effect.
- One-route without store – bottles/jars are utilized by the client, the maker – in the best case-will pay a charge to an association to deal with the waste or will simply have nothing to do with their item once it ends up squander. People in general specialists will bear the expenses and a decent measure of the refreshments should be landfilled or consumed. High litter, high natural effect however least expensive choice for the makers.

But deposit systems are not only good for the environment and an excellent tool to implement Extended Producer Responsibility, they also save lots of money to the municipalities by lowering the volume of household waste to be managed (in some cases up to 50%), reducing the pick-up frequency, reducing the need for sorting and disposal facilities such as incinerators and landfills and by reducing the need for street cleaning. Less cost for the municipalities means less cost for the tax-payers.

2.6 Zero Waste in UM

University Malaya amplifies reusing to limit its waste.

With populaces that keep running into the thousands, every college grounds is a network in itself, producing as much junk as say, a town. Their disposes of can be anything from five to eight tons every day. With there being 20 public universities and 200 private ones in the country, it is estimated that the trash from these academic institutions amount to some 1,500 tonnes a day. All these wastes contribute between 5% and 10% of the country's total waste and almost all are dumped into landfills. With the nation condition of delivering 33,000 tons of waste every day, it's an appropriate issue that should be settled. Alternative options shall be considered and not only solely relying on the Government.

And that is the push behind UM's Zero Waste Campaign. The plan began on reusing by understudies in the natural building division in 2009 and extended to incorporate isolation of nourishment and garden squanders for fertilizing the soil. In late 2010, it developed into the yearning Zero Waste Battle (ZWC) with subsidizing from CIMB Establishment. Today, beside reusing the standard paper, plastics and metals, squanders, for example, nourishment scraps, cultivate trimmings, materials, hardware and wood are likewise occupied from landfills.

Waste management is not just waste treatment. It is mind boggling as it is tied in with overseeing waste. It involves different angles, for example, age, accumulation, reuse, reusing and transfer. Waste, if recovered, can be a resource. Waste disposal hierarchy should be looked in a more detail manner. Priorities should be given on reducing, reusing, recycling, processing and lastly just landfill on the off chance that we can't do anything with it. Guided by that theory, the ZWC group received a multi-pronged methodology as the different waste-types must be managed in an different ways.

It additionally works together with different privately owned businesses to guarantee legitimate treatment of the loss after accumulation from grounds. As a begin, the arrangement of reusing containers everywhere throughout the grounds energizes waste division. The recyclables are gathered by janitors and sold to recyclers. To guarantee legitimate transfer of electronic waste, there is a drop-off container at the ZWC venture site situated at the college's waste stockpiling territory. Periodically, uncommon accumulations and pick-ups are composed for e-waste, which is then reused by the organization T-Pot E and E.

Reusing waste

A key focal point of the battle is natural waste since that structures between half to 60% of the aggregate waste being delivered our aggregate disposes of. Ignoring organic waste means ignoring the major part of the problem. Organic waste when just left open in the environment will slowly decompose due to the presence of bacteria in the environment. As part of this decomposing process, methane gas will be released to the environment. Methane gas is also part of the greenhouse gases. Although its composition is not as much as carbon dioxide, however, its impact is nearly 21 times greater than that of carbon

dioxide. Overcoming organic waste alone can mitigate half of the problems related to greenhouse gas emission.

As part of mitigating this problem, the ZWC team in UM has taken steps to recycle food waste into compost. Since, there are many cafeteria operating inside campus area, it is definitely a good step to start with those operating cafeterias. Café operators will have to source separate their food waste into recyclables and non-recyclables to ease the process of composting. Besides food waste, landscape waste such as grass, dried leaves and other organic material are mixed together and sent to storage area. Here, the waste are left to undergo aerobic digestion by microbes.

As part of this effort, CH Green, a private company has lend a helping hand in providing machines for this digestion to take place. In return, the UM team will continue to research on this proposed method to increase its efficiency. Once the compost is ready, it can be used as a fertilizer for plants and crops. Some of the biogas produced is also used as a cooking gas. Since the volume produced is still low, hence it cannot be collected to generate electricity. This scheme has resulted in quite a saving to the university. It also leads to savings in transport costs, fuel and tipping fees as well as non-tangible benefits such as emission reductions and environmental protection.

Until December 2014, over 145,300 kg of organic waste has been treated, producing 4,700kg of compost and curbing the emission of 70 tonnes of carbon dioxide equivalent. Challenges remain such as the need to purchase the white plastic bags. Some 80 bags are given free initially. To counter that, the team plans to seek the help of the university

administration to subsidise the bags. Continuous campaigning is needed to educate food outlet operators as they change when contracts expire.

Saving old clothes

To handle textile waste, the team collaborates with a recycler, Life Line Clothing. The collaboration started a year ago with only two drop-off bins. Now, there are 10 bins all over the campus for people to dispose of their old clothes and household textiles such as curtains and bedsheets. Old toys, bags and shoes are also accepted. Life Line donates a certain sum (undisclosed) for every kilogramme of waste dropped into the bin, to three charities namely the Malaysian Association for the Blind, Spastic Children's Association of Selangor and Federal Territory, and the National Cancer Council.

Some three tonnes of wastes are collected each month. At the textile recycling factory located in Port Klang, the items are graded. The usable items are sold as second-hand goods here as well as shipped abroad. The rest are turned into industrial cleaning rags or sent to another facility which processes the waste into fuel. In December, the campaign expanded to cover wood waste mainly from old furniture and tree cuttings. Some five tonnes are collected each month. The waste is used by TSP Waste Management to run boilers in its paper mill in Rasa, Selangor, thus avoiding the use of fossil fuel.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This section clarifies in points of interest the philosophy for quantifying waste reduction and revenue saved based from converting food waste to liquid compost. The research is best communicated as the methodology on how research or information accumulation will be directed. The synopsis of research for this research is illustrated in **Figure 3.1**. The flow chart demonstrates the path from the earliest starting point until the point when the task is finished. Besides, tools, for example, SPSS tool will be utilized to quantify waste reduction and revenue saved based from converting food waste to liquid compost. Target area for sampling and questionnaires designed will also be briefly explained.

3.2 FLOW CHART

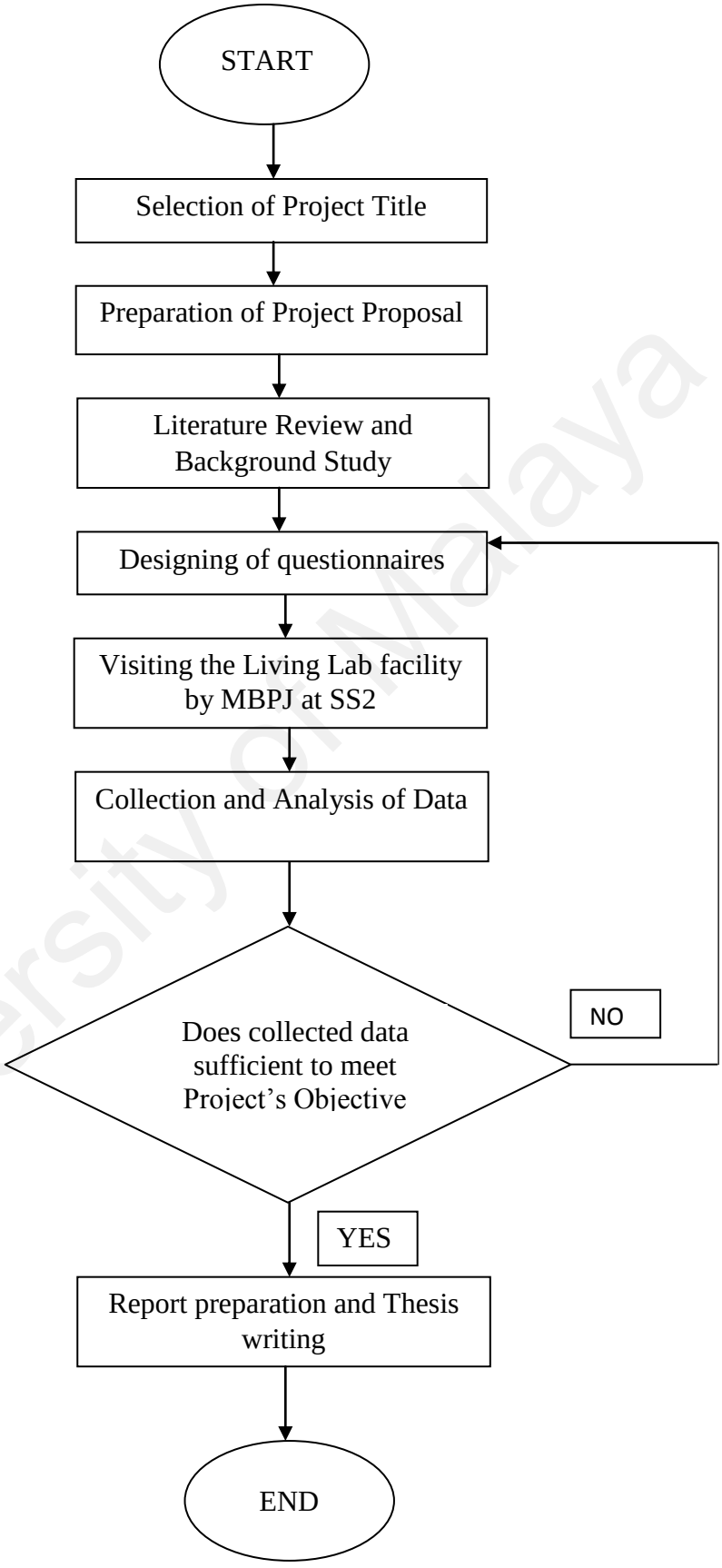

Figure 3.1: Project Flow Chart

3.3 SUMMARY ON ACHIEVING OBJECTIVES

In this subtopic, strategies to accomplish the goals of this research will be clarified. In this research, there are three objectives. Therefore, an overview to accomplish the objectives are described in **Table 3.1** beneath.

Table 3.1: Methodology Summary

No	Objectives	Method Involved
1	To assess public awareness on the importance of recycling household waste focusing on food waste	a) Questionnaires to public household -minimum of 30 respondents b) SPSS Statistics Software
2	To investigate hawker's awareness on the importance of proper food waste management.	Questionnaires to hawker stalls at SS2 -minimum of 30 respondents
3	To quantify how much money can be saved based on the case study	a) Questionnaires to MBPJ Operators - to estimate revenue and expenditure from composting process b) SPSS Statistics Software

3.3.1 Target Sampling Area and Methodology Scope

Sampling area will be targeted to hawker stall owner's at SS2 and also household around Petaling Jaya. Sampling will follow simple random sampling method where all of the population has an equal chance of being chosen. The scope of the methodology will include timeframe, materials, boundaries and any related issues. Scope of methodology is shown in **Table 3.2** below.

Table 3.2: Scope of Methodology

Scope	Explanation
Timeframe	Data will be collected for a period of 6 months from January until June
Material Type	- Food waste from hawker stalls - Crops grown at MBPJ Facility - Liquid compost from the composting process
Boundaries	Geography: Petaling Jaya Organization: MBPJ : Hawker Stalls at SS2 : Household near Petaling Jaya
Other issues	Maintaining close loop cycle for the entire process

3.4 STEPS INVOLVED IN METHODOLOGY

In this section, detailing steps beginning from designing of questionnaires until data analyzing will be discussed.

3.4.1 Designing of Questionnaires and Interview

Questionnaires were designed to meet the primary objectives of the research. These were done by giving out questionnaires to the waste operators at MBPJ, hawker stall owners at SS2 and household around Petaling Jaya. Some of the areas covered in the questionnaires and interview session are:

i. Awareness on waste management
ii. Awareness on recycling activities
iii. Daily waste production
iv. Food waste handling by restaurant owners

v. Composting process

vi. Charges for landfilling process

vii. Operating cost and revenue information for composting process

viii. Energy and water consumption

Detailing aim of each questions are described in the **Table 3.3**, **Table 3.4** and **Table 3.5** below.

Table 3.3: Contents of Questionnaires with MBPJ Waste Operators

Question Number	Purpose of Question
1	The question aims to measure the total amount of food waste collected on monthly basis. Besides, it also aims to investigate the fees required if the waste is directly sent to landfill.
2	The question aims to identify the compost is being produced in what form and how it is being packed.
3	The question aims to calculate the revenue from the sale of compost and crops
4	The question aims to calculate the operating cost required from the composting process.
5	The question aims to estimate percentage of waste can be diverted from landfill with composting process.

Table 3.4: Contents of Questionnaires with Hawker Stall Owners

Question Number	Purpose of Question
1	The purpose of the question aims to investigate how long the stall have been operating
2	The purpose of the question aims the owner's awareness on food wastage
3	The purpose of the question aims to identify the sources of food wastage from the stall
4	The purpose of the question aims to find out ways to reduce food

	wastage.
5	The purpose of the question aims to investigate the obstacles faced in reducing food wastage
6	The purpose of the question aims to estimate generation of food wastage daily
7	The purpose of the question aims to identify what will be done to the left over food
8	The purpose of the question aims to estimate distance needed to travel to dispose/recycle food waste
9	The purpose of the question aims to investigate how much effort will owner put to reduce food wastage if there are incentives

Table 3.5: Contents of Questionnaires with Household Owners

Question Number	**Purpose of Question**
1.1 – 1.7	The question aims to study the socioeconomic background of the population
1.8	The question aims to identify the type of residence
1.9	The question aims to study who is usually responsible to dispose waste
1.10	The question aims to study food waste segregation with othe household waste.
2	The question aims to study on recycling awareness among the respondents
2.2	The question aims to study on knowledge of recycling among the respondents
2.3	The question aims to investigate any improvement can be done on recycling activities
2.4	The question aims to investigate how respondent can contribute more towards recycling activities.

3.5 DATA COLLECTION

For objective one to assess the public awareness on the understanding of food waste management, SPSS Statistics software was used. Basically, this software is used to calculate the frequency for the age of respondents, frequency of respondents that separate their food waste and frequency of respondents that send their food waste for composting. For objective two to assess awareness of hawker's on importance of proper food management, data was collected by using Microsoft Excel. For objective three, to quantify revenue obtained by converting food waste to liquid compost, data was obtained by giving questionnaires to the waste operators and MBPJ authorities.

3.5.1 Operating Cost

Operating cost includes costs that are required to carry out the composting process. Comparison will be done to investigate difference in operating cost if it is directly sent to landfill or sent for composting. Some of the operating costs intended to be measured are electricity consumption, water consumption and fuel consumption by dump trucks. Data for electricity consumption and water consumption will be obtained directly from MBPJ while data for fuel consumption will be measured based on the distance travelled by dump trucks daily. Besides that, there is also one time cost incurrence such as money spend to buy the composting machines and also to pay the salary of workers. In this case, the cost of machineries and salary of workers are paid according to tender bidding. Every two years, there will be an open tender to manage the maintenance of the machines and also to pay the salary of the workers. For the first two years of this Smart Waste Lab operation, the tender was given to CH Green with a valuation of RM 850,000. However, in the calculation of revenue, the cost for tender valuation was excluded. This is because; the focus is to study

the revenue that can be saved from converting food waste to liquid compost in daily operating process.

3.5.2 Revenue

With the production of compost, it can be directly sold to public or even use internally for the production of crops and fruits. Hence, this will be considered as profit. Reduction of number of trips to landfill site is also considered as saving. **Table 3.6** below shows the proposed method for calculating the revenue

Table 3.6: Revenue from the sales of compost and crops

Month	Average revenue from sale of liquid compost (RM)	Average revenue from sale fruits/crops (RM)
January to June		

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

In this chapter, the results obtained through the questionnaires distributed will be analyzed and discussed in detail. All the data are collected from January to June 2018. The first objective to assess public awareness on the importance of recycling household waste focusing on food waste will be analyzed through Statistical Package for the Social Sciences (SPSS). The second objective to investigate amount of food waste reduction was done by distributing questionnaires to three specific locations randomly. The third objective to quantify revenue obtained through the close loop cycle was done by visiting and interviewing the waste operators and local authorities at Smart Waste Solution Lab SS2 PJ.

4.2 ANALYSING PUBLIC QUESTIONNAIRES

A set of 30 questionnaires were randomly distributed among households in Petaling Jaya to assess public awareness on their understanding on food waste management. Basically, questionnaires were aim to determine whether respondents do separate their food waste with other household waste and what is done when there is excess food at home based on different age group. SPSS Statistics software was used to analyze the frequency and the relationship between age group and their habits related to food waste management.

Age group was ranging from 18 years to 65 years. **Figure 4.1** below shows the frequency of the age groups. As can be seen, the mode of distribution of the respondents was between the age group of 23-35.

age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-22	5	16.7	16.7	16.7
	23-35	19	63.3	63.3	80.0
	36-45	5	16.7	16.7	96.7
	56-65	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

Figure 4.1: Frequency of Respondents based on Different Age Group

As discussed, two categories are being focused which are food waste separation at home and solution to excess food at home. The aim is to investigate if there are any relationship between age group and if they separate food waste at home. **Figure 4.2** below shows the frequency of respondents that separate food waste with other household waste at their home.

foodwasteseperation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	16	53.3	53.3	53.3
	no	14	46.7	46.7	100.0
	Total	30	100.0	100.0	

Figure 4.2:Number of Respondents that Separate Food Waste at their Home

As can be seen, slightly more than half of the respondents separate their food waste from other household waste. Out of 30 respondents, 16 separate while 14 does not separate

their food waste with other household waste. To determine the relationship with age group, a bar graph was plotted. **Figure 4.3** below shows the relationship between age group and their tendency to separate food waste.

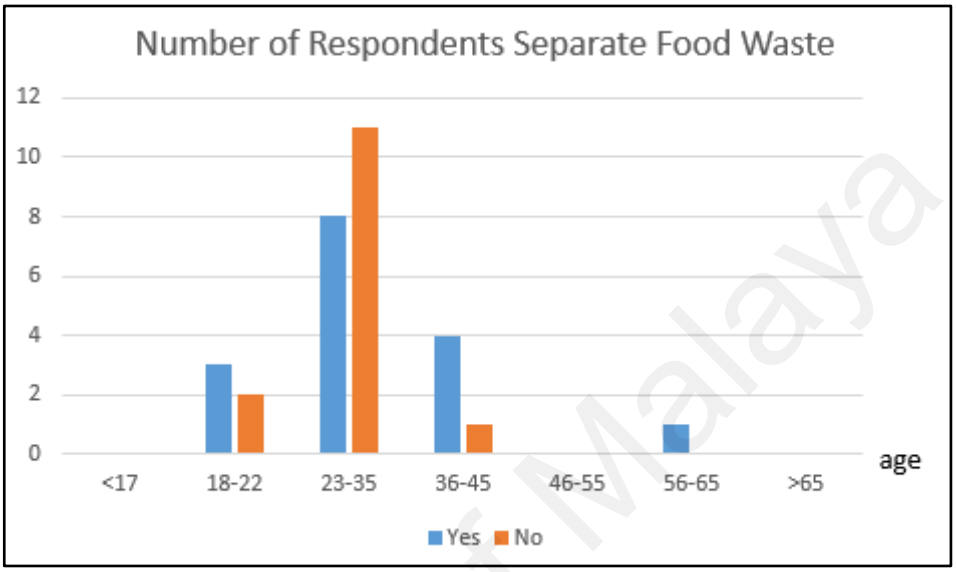

Figure 4.3: Number of Respondents Separate Food Waste

As can be seen, most of the respondents stated they will separate their food waste except for age group 23-35 slight more stated they will not separate. This shows that most of the respondents are aware on the importance to separate their food waste. However, what is done the food waste after it is separated. **Figure 4.4** below shows the frequency of respondents on what is done if there is excess food at home. Three options were given in the questionnaire which included giving to charity, send for composting or dispose in rubbish bin. Sadly, 90% of the respondents choose to dispose excess food in rubbish bin which will be sent to landfill.

excessfoodwaste

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	give to charity	1	3.3	3.3	3.3
	send for composting	2	6.7	6.7	10.0
	dispose in bin	27	90.0	90.0	100.0
	Total	30	100.0	100.0	

Figure 4.4: Solution to Excess Food Waste

The relationship between age group is shown in **Figure 4.5** below.

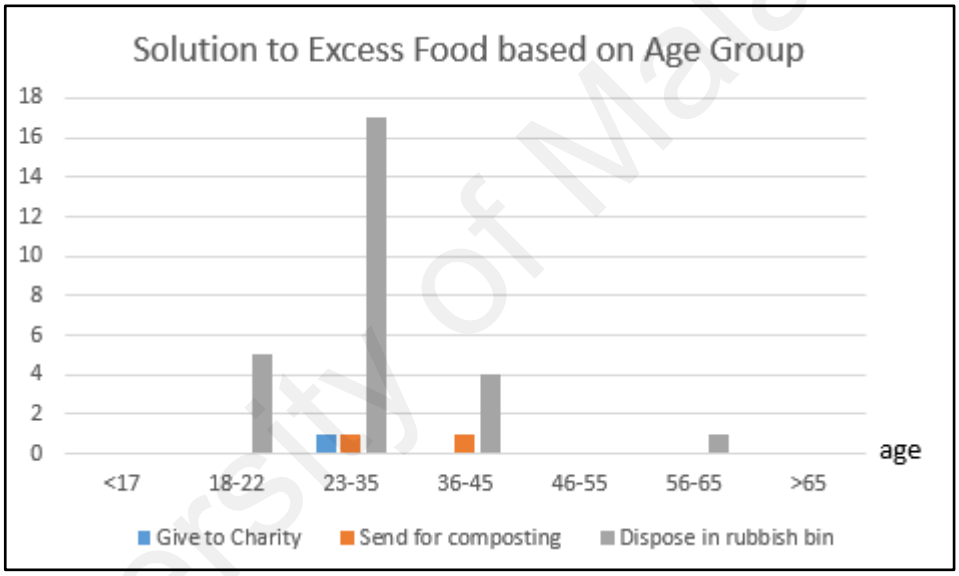

Figure 4.5: Relationship between Age Group and Solution to Excess Food

As can be seen, although more than 50% of the respondents separate their food waste, but 90% of the respondents dispose their food in rubbish bin if they have excess. Only 2 respondents sent their food waste for composting. This shows the awareness level among public is still very low on the importance to compost food waste instead of disposing in rubbish bin.

4.3 ANALYSING HAWKER'S QUESTIONNAIRES

Generally there were three locations where the questionnaires were distributed. The three locations are Ibumie Selera Makan, Selera Malam and morning market. A total of 10 questionnaires are randomly distributed at each of these locations. The objective of distributing this questionnaires is to identify the common sources of food waste, obstacle to reduce food waste, and the owner's effort to recycle the food waste. The graphs below shows the result obtained.

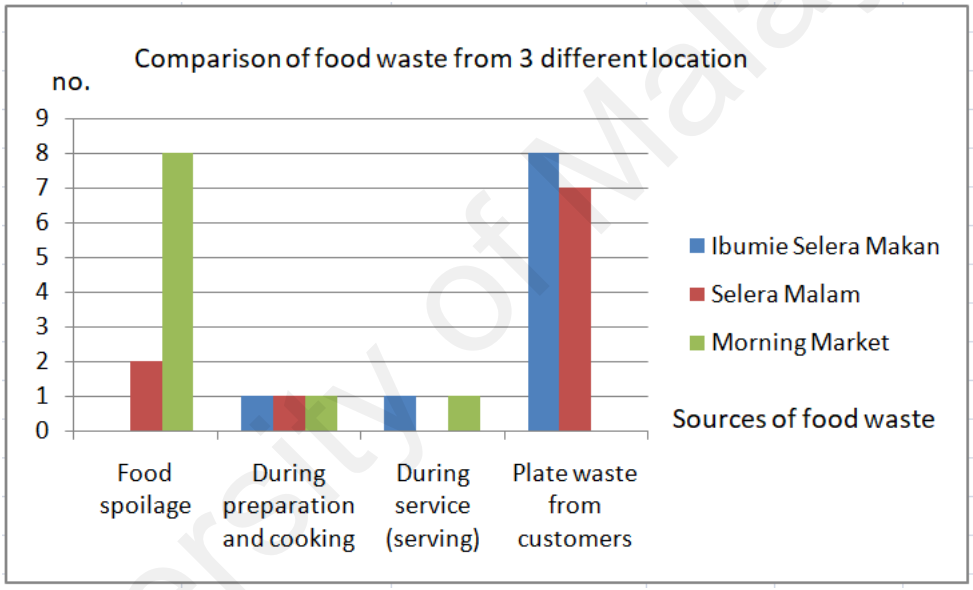

Figure 4.6 : Comparison of food waste from 3 different location

From the **Figure 4.6** above, it can be seen that highest source of food waste for Ibumie and Selera Malam is coming from plate waste from customer. This maybe due to the habit of Malaysian customer that always tend to left over their food. However for morning market the highest source of food waste is due to food spoilage. This is because at certain times there are extra supply or resources compared to demand. Another reason maybe due to over riped of fruits and causes it to easily rotten when they cannot be sold on time.

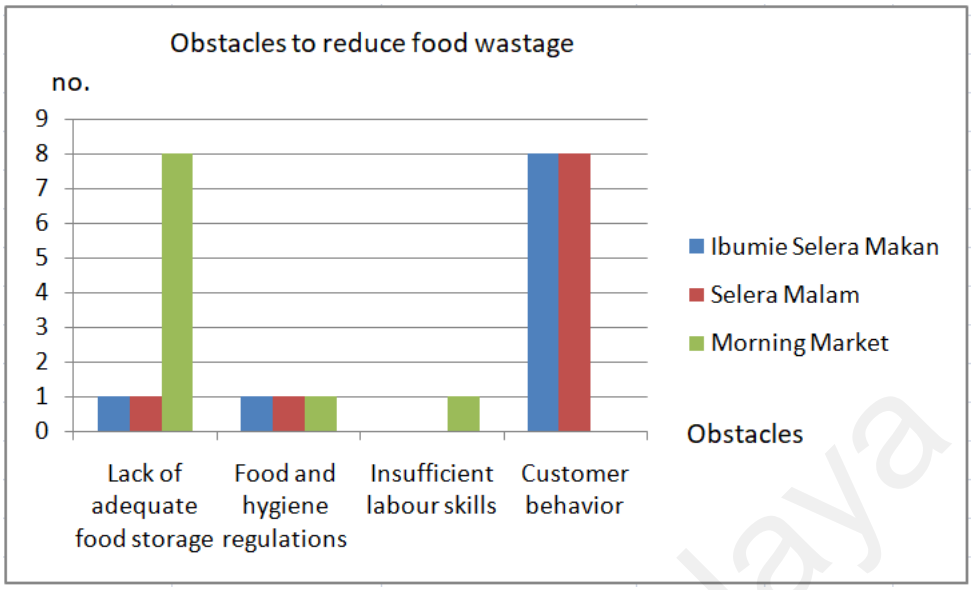

Figure 4.7 : Obstacles to reduce food wastage

From the **Figure 4.7** above it can be seen that the highest obstacles for Ibumie and Selera Malam is coming from customer behavior. This may due to customer's inability to estimate the amount of food they could consume or due to over ordering of food. For morning market the highest obstacles is lack of adequate food storage. This may due to insufficient of place for storage. Therefore, they leave the crops or fruits in normal environment instead of placing the crops inside the refrigerator. The high temperature and humidity of our weather maybe the sole reason these crops get easily spoil and rotten.

Figure 4.8: Solution to excess food waste

From the graph shown in **Figure 4.8** above it can be seen that most of the operators choose composting and landfill as an option to excess food waste generated at their shops. It can be concluded that nearly 50% choose composting while another 50% choose landfill which reflects the survey conducted with the MBPJ authorities stating that only roughly 50 % of the shop owners contribute their food waste to the Smart Waste Solution Lab.

Figure 4.9 : Effort to reduce waste

From **Figure 4.9** above, it can be clearly seen that almost all of the shop owners will put a great deal of fair amount of effort to reduce food waste being generated at their shop if this activity is incentivized. It clearly shows that the act to reduce food waste can be encouraged by giving them some reward.

4.4 REVENUE FROM CIRCULAR ECONOMY IMPLEMENTATION

Table 4.1 below shows income selected and expenditure spent from the close loop cycle being implemented at Smart Waste Lab SS2 Petaling Jaya

Table 4.1 : Income Selected and Expenditure Spent

Income	Expenditure
- Sales of compost - Sale of crops - Tipping fee that can be avoided to the landfill - Fuel price that can be avoided by reducing from 3 to 2 trips of dump truck	- Electricity bill - Water bill

4.4.1Income

Sales of compost and crops from January to June 2018 show in **Table 4.2**below

Table 4.2 : Sales of Compost and Crops

Month	Average revenue from sale of liquid compost (RM)	Average revenue from sale fruits/crops (RM)
January to June	1250	680

Source : Majlis Perbandaran Petaling Jaya

Since all these food wastes are being composted at the nearby facility, hence all these food waste can be diverted from going to the landfills. Therefore, cost required to send the waste to landfill can be avoided and considered as savings.

i) Tipping fee that can be avoided

The tipping to dispose 1 tonne of solid waste is RM 36. Therefore, the tipping fee that can be avoided is considered as savings is shown in **Table 4.3**below

Table 4.3 : Tipping Fee that can be avoided

Month	Food waste (tonne)	Tipping fee that can be avoided (RM)
January	12.862	12.862 tonne x RM 36 = RM 463.03
February	8.601	8.601 tonne x RM 36 = RM 309.64
March	14.054	14.054 tonne x RM 36 = RM 505.94
April	32.464	32.464 tonne x RM 36 = RM 1168.70
May	11.108	11.108 tonne x RM 36 = RM 399.89

June	10.223	10.223 tonne x RM 36 = RM 368.03
		Total = RM 3215.23

ii) Reduction of trips by dump trucks

Initially = 1 day 3 trips

Now = 1 day 2 trips

Landfill to Jeram landfill located approximately 42 km / way

Total = 84 km / day

Fuel consumption of dump truck is approximately 3.5 km / litre

∴ Fuel consumption saved in 1 day

= 84 km / 3.5 km

= 24 litres

Currently 1 litre of diesel is RM 2.18

Hence, money saved is = RM 2.18 x 24

= RM 52.32

From a period from January to June, a total of 181 days

∴ RM 52.32 x 181 = RM 9469.92

Total income generated

= sales of compost + sales of crops + tipping fee that can be avoided + fuel price that can be avoided

= RM 1250 + RM 680 + RM 3215.23 + RM 9469.92

= RM 14615.15

4.4.2 Expenditure

i) Electricity Bill

Electricity bill from the month of January until June is shown in **Table 4.4**below

Table 4.4 : Electricity Bill

Month	**Bill**
January	RM 52.00
February	RM 33.90
March	RM 28.00
April	RM 45.64
May	RM 47.45
June	RM 50.55
	Total = RM 257.54

ii) Water Bill

Table 4.5: Water Bill

Month	**Bill**
January	RM 194.20
February	RM 336.25
March	RM 577.23
April	RM 1176.44
May	RM 1224.78
June	-
	Total = RM 3508.90

∴ Total Expenditure = electricity bill + water bill

= RM 257.54 + RM 3508.90

= RM 3766.44

Revenue = Income – Expenditure

= RM 14615.15 - RM 3766.44

= RM 10848.71

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

As a conclusion, it can be see that revenue can be generated by the implementation principles of the circular economy. The effort taken by Majlis Bandaraya Petaling Jaya (MBPJ) definitely resulted in a positive way as a profit of over RM 10 k per six month was achieved. Initially, residents or hawker stall owners used to throw their waste into the dustbin which directly goes to the landfill which resulted to a cost of over RM 14 k to manage these waste. However, after implementation principles of the circular economy close loop system, MBPJ come up with the system to convert the food waste into compost which resulted in avoiding all food waste to end up in landfill. The process involved at Smart Waste Lab SS2 is that hawkers from Ibumie Medan Selera, Selera Malam and morning market send their waste to the lab and then it undergoes separation process, shredding and finally anaerobic digestion to be converted into a compost. Hence, the objective to quantify the revenue from the process of converting food waste to liquid compost is clearly achieved. For the sub objective to investigate hawker's awareness on importance of proper food waste management was also achieved as the questionnaires distributed were able to investigate the sources, obstacles of food waste management and at the same time effort they will put to reduce food waste at their premises. The last sub

objective to assess public awareness were also achieved as the questionnaires distributed were able to assess public's habit on whether to separate food waste and their understanding on recycling at home.

The projection on future savings is one year savings is equivalent to approximately RM 20,000. Currently there are around 149 local authorities in Malaysia. If all these local authorities duplicate the initiative as MBPJ huge savings can be achieved.

For example RM 20,000 x 149 local authorities = RM 2 980 000 per year

For return of investment (ROI),

$$\text{Average annual profit} = \frac{\text{Total gains} - \text{Total outlay}}{\text{Number of years}}$$

ROI = (Average annual profit / Original Investment) x 100 %

An assumption is made that the composting machines can last up to 10 years

Year	Cashflow (RM)
0 (tender valuation)	800,000
1	20,000
2	20,000
3	20,000
4	20,000
5	20,000
6	20,000
7	20,000
8	20,000

9	20,000
10	20,000
Total gains	200,000

The tender valuation is RM 800,000 which is the cost of the composting machines and the salary of the workers.

Profit = 200,000 – 800,000

= - 600,000

Annual profit = - 600,000 / 10 years

= - RM 60 000

Hence ROI = [-(RM 60 000) / 800,000)] x 100 %

= - 7.5 %

Although it is negative in terms of money, it is positive in terms of savings the environment and can divert waste away from the landfill. To convert into positive return of investment (ROI) is by increasing the food waste collection area and fully utilize capacity of composting machine.

5.2 RECOMMENDATIONS

Effort initiated by MBPJ to set up Smart Waste Solution Lab is worth giving credit. As discussed, in a period of six months, the facility can record a revenue RM10,848.71. In a matter of a year, the profit approximately would be able to double to an amount RM21697.42. Besides generating revenue, this system also could divert waste away from

landfill resulting in lower carbon emission leading to a more sustainable environment. Such a big difference one facility could make to the nature.

5.2.1 Recommendation for Future Study

There are few recommendation proposed to make the results obtained more impactful. Firstly, the duration for data collection can be increased from six months to one year. Next, for the revenue calculation, onetime cost incurrence such as the tender valuation can also be included to obtain the exact figure for savings. Moreover, for objectives one and two to investigate the awareness of household and hawkers on waste management, more questionnaires could be distributed to get a better response results.

5.2.2 Recommendation to the Government

A point of recommendation here is what if other states in Malaysia look into this system and learn what MPBJ is doing. By duplicating the same system as MPBJ, waste to landfill can be reduced and at the same time income can be generated. Besides that, carbon emission to the environment can also be reduced. The revenue received from this circular economy closed loop system can be invested to set up other facilities with the same purpose. In order to encourage other local city councils in incorporating this initiative, local state government can either provide incentives or conducting awareness program to ensure this initiative can result in a success.

As part of MBPJ carbon management plan from year 2015 – 2030, revenue obtained can also be projected. **Table 5.1** below shows the estimation cumulative revenue can be generated.

Table 5.1: Estimation Cumulative Revenue

Year	Estimation Revenue (RM)
2018	RM 21697.42
2019	RM 43394.84
2020	RM 65092.26
2021	RM 86789.68
2022	RM 108487.10
2023	RM 130184.52
2024	RM 151881.94
2025	RM 173579.36
2026	RM 195276.78
2027	RM 216974.20
2028	RM 238671.62
2029	RM 260369.04
2030	RM 282066.46

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