A SYSTEM DYNAMICS APPROACH FOR ORGANIC WASTE MANAGEMENT IN TRADITIONAL MARKET

UNDERGRADUATE THESIS

Submitted to the International Undergraduate Program in Industrial Engineering in Partial Fulfilment of Requirement for the Degree of Sarjana Teknik at the Faculty of Industrial Technology
Universitas Islam Indonesia

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UNDERGRADUATE PROGRAM IN INDUSTRIAL ENGINEERING
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YOGYAKARTA
2024

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A SYSTEM DYNAMICS APPROACH FOR ORGANIC WASTE MANAGEMENT IN TRADITIONAL MARKET

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DEDICATION PAGE

I sincerely say thank you to my parent, who are always there to aid me in my time of need anytime, anywhere, whether they are busy or not, by providing me with moral, spiritual, and financial support for me to be able to continue living my life by giving me the essential needs for me to survive in this world and also my caring younger and older sister to aid by giving your moral support.

I am very proud of myself for being able to fight all the obstacles that are coming to me and withstand the physical and mental strain to reach this point. After finishing my study at this university, I must be much more ready for after this I will be going to the world of work where I must endure much more than what I have gone through.

For all the lecturers in the Department of Industrial Engineering international program of this university, Universitas Islam Indonesia, I am grateful for the knowledge and practical skills that are being taught here, which will be useful later down the road.

And lastly, I want to thank all my friends in my class for helping me throughout this university; I am very grateful for that.

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MOTTO

"And be patient. Verily Allah is with those who are patient."

-Q.S. Anfaal [8]: 46

"And seek help through patience and prayer. Indeed, it is a burden except for the humble"

-Q.S. Al-Baqarah [2]: 45

PREFACE

With praise and gratitude, the writer conveys the presence of Allah SWT, who has bestowed his grace and guidance so that the author can complete the undergraduate thesis report without any problem. Salawat and greetings, may it always be devoted to our lord, the Great Prophet Muhammad, who brought and illuminated our conscience and became a light for all noble deeds. And God willing, we all include the people of Prophet Muhammad SAW until the end of time.

This undergraduate thesis is evidence of the implementation of the company workflow and fulfilling one of the requirements to achieve a bachelor's degree in the Department of Industrial Engineering, Universitas Islam Indonesia.

The author is fully aware that in the preparation of this undergraduate thesis report, there are not a few difficulties and obstacles experienced by the author, both in terms of content, writing, and words that are not well structured, but thanks to the help and guidance of various parties, finally this undergraduate thesis can be completed. With a sincere and sincere heart, the author would like to express his gratitude and gratitude and appreciation to:

1. Prof. Dr. Ir. Hari Purnomo, M.T., IPU, ASEAN.Eng as Dean of Faculty of Industrial Technology, Universitas Islam Indonesia.
2. Dr. Drs Imam Djati Widodo, M.Eng.Sc., as Head of the Department of Industrial Engineering, Universitas Islam Indonesia.
3. Muhammad Ridwan Andi Purnomo, S.T., M.SC, Ph.D., IPM. as Head of Undergraduate Program in Industrial Engineering, Universitas Islam Indonesia.
4. Ir. Ira Promasanti Rachmadewi, M.Eng., as Secretary of the International Undergraduate Program in Industrial Engineering, Universitas Islam Indonesia.
5. Dr. Agus Mansur, S.T., M.Eng.Sc, IPU. as the undergraduate thesis supervisor, has guided me in completing the author’s undergraduate thesis.
6. The author’s parents have provided moral, spiritual, and financial support to be able to finish this undergraduate thesis.

Finally, the author says, Alhamdulillah, may Allah SWT always accompany the steps of the writer Amin. Hopefully, this undergraduate thesis can be useful and can add insight into thinking as well as reference material and information that is useful for knowledge, especially in the field of industry.

ABSTRACT

Waste that is not appropriately managed becomes worthless and hurts the surrounding environment. The Tempel market in Selman became a waste collection point for markets around Selman when the Piyungan landfill was closed. Waste management helps reduce waste accumulation and turn worthless waste into more valuable. A waste management design proposal to mitigate negative impacts and maximize land utilization was made in this study. A dynamic system approach was taken to assist decision-making. Many factors make waste generation dynamic and complex, so a dynamic system approach can make it easier to help make better decisions. Waste reduction focuses on organic waste. BSF larvae can reduce organic waste by 320,000 kg over the next five years. Waste reduction using BSF larvae also allows worthless waste to be converted into something new and valuable. The BSF larvae can be sold for animal feed, and the compost fertilizer from the larval bed can also be sold. Calculating the payback period for implementing waste management improvements using BSF larvae takes 11 months to pay back. In less than a year, this waste management project can return the capital spent for the first time by the manager, so the business implementation for this management is feasible.

Keywords: System Dynamics, Larva BSF, waste management,

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CHAPTER I

INTRODUCTION

1.1 Background

Based on data from the Indonesian Ministry of Environment and Forestry, in 2022, with a population of 12 million, it can produce waste with a volume of 1.9 million M3/day. Meanwhile, the new government can collect and transport 60-70% of the total waste. Waste management must be conducted comprehensively and integrated from upstream to downstream to provide economic benefits, be healthy for the community, be safe for the environment, and change people's behavior. With a suitable waste management model, the surrounding environment can be maintained, and the community is protected from various diseases. In addition, waste management also requires legal certainty, clarity of responsibilities, and division of authority in addition to the role of the community and the business world in waste management, which can support the waste management system. This is related to RI Law No. 18 of 2008 concerning Waste Management in Indonesia. This law regulates waste management, distribution of authority, and its implementation. (Firman L. Sahwan et al, 2010).

A traditional market is a meeting place between sellers and buyers, including facilities supporting sellers to display their selling items. A market is where sellers and buyers meet and are marked by direct seller and buyer transactions. The building usually consists of outlet stalls, stalls, and open grounds by the seller or one market manager (Oliver, 2019). Meanwhile, in a broad sense, it is defined as a meeting place for sellers who can sell goods/services and buyers who use the money to buy goods at a specific price. Sleman Regency is an urban area of 574,82 KM2 with a population of 1,136,474 people. The population, according to (Badan Pusat Statistik) BPS Sleman is constantly increasing by 1-2 %. A large part of the population increased the need for people's lives. Even though online shopping is more popular than the traditional market, it will not be able to eliminate the conventional market. According to the Decree of the Regent of Sleman No. 97/97/Kep.KDH/A/2012, there are 22 traditional markets spread across various regions of

Sleman Regency, so the market waste produced is also increasing and more diverse. However, waste management has not been conducted optimally, so waste products in the market are still significant.

Buying and selling activities in traditional markets generate waste that needs to be appropriately managed. Poor management will cause many losses ranging from health and the environment to the beauty of the view. By doing good waste management, it will reduce the existing losses. According to John Pitchel in his book, waste management practice shows domestic waste generated from the market. Domestic waste management is conducted in several ways, such as recycling, composting, incineration, and landfilling. Waste Management that can increase the value of the waste itself can be done by recycling and composting. The waste produced by traditional markets has a composition such as food waste, leaves, plastic, paper, and wood. Waste management in traditional markets can provide economic income for market managers. Garbage is something that looks annoying and causes harm. However, proper management of waste will have economic value.

Managing waste will increase the economic value of the waste. In addition, waste management can also reduce the negative impact of existing landfills. This research was conducted in the Sleman traditional market, with an average daily waste production of 754 kg/day. With much daily waste generated by the traditional market and the lack of research on waste management in the traditional market. The author wants to design waste management in traditional markets by comparing composting techniques to generate economic value for the management of the traditional market.

1.2 Problem Formulation

Based on this background, the problem formulation is as follows:

1. How to determine the most appropriate organic waste management technique to obtain high economic value?
2. What is the economic value of the waste generated in the traditional market?

1.3 Research Objectives

Based on the formulation of the problem, the research objectives are as follows:

1. Finding the proper waste management technique to solve the waste problem in the traditional market.
2. Finding the projection waste generation in the Tempel market
3. Giving advice to additionally policy determine for the Tempel market management.

1.4 Scope of research

The scope of the research includes the following:

1. The study exclusively focused on the traditional market in the Selman district.
2. Research was only conducted on organic waste.
3. The research relied solely on simulations derived from the collected data.

1.5 Benefits of Research

Many parties can use the benefits of the research that will be obtained with the following details:

1. For College Students, this research is expected to provide applied theory and its relevance as a preparation before entering the world of work and measure the abilities or skills to gain new experience.
2. For the government, this research is expected to become a reference for improving the performance of a business or industry so that more people are interested in building businesses and impacting economic development in the community.
3. For subsequent researchers, this research is expected to become a future reference and will be developed more by future researchers who have some interest in this undergraduate thesis.

1.6 Systematic Research

This undergraduate research will be organized into several chapters, which will be explained below:

CHAPTER I INTRODUCTION

The introduction contains the background for the undergraduate thesis and the problem formulation. Besides that, it also contains the objectives of the research, the scope of the research, and the benefits of the research.

CHAPTER II LITERATURE REVIEW

Chapter 2 will summarize the findings from the prior studies and research that are relevant to this research. After thoroughly reviewing the prior studies and research, it will become a reference for this undergraduate research to resolve the existing problem.

CHAPTER III METHODOLOGY

This section describes the framework, flow chart, and data collection method of this undergraduate research. This will help to make the research more structured and organized. Here, the flow of the research will be explained in detail so that the readers can understand the research methodology.

CHAPTER IV DATA COLLECTION AND PROCESSING

This chapter describes the data collection in the form of an overview of the problem issue data collected from the object and further processed based on the economic view.

CHAPTER V RESULT AND DISCUSSION

The outcomes of this research will be discussed in chapter 4. The result of the research will be analyzed subjectively using theoretical explanations and statistically based on the research findings and studies. The findings needed to satisfy the research objectives. Based on the analysis in this chapter, there will be recommendations on the waste management process that give the good economic condition.

CHAPTER VI CONCLUSION AND SUGGESTION

Chapter 6 is a closing that contains conclusions and suggestions regarding the undergraduate thesis. The conclusion is based on the result and discussion and must answer the research's objective.

CHAPTER II

LITERATURE REVIEW

2.1 Literature review

Final assignment research with the title "Study of Generation, Composition and Management Planning of Market Waste (Case Study in The Market Area Of Sleman Regency, Yogyakarta)" written by Iswadianto, Environmental Engineering Student at the Islamic University of Indonesia in 2018 shows that the level of traditional market waste management in traditional markets in the Sleman area not managed well. The waste generation sampling method conducted referring to SNI 19-3964-195 resulted in the waste generation produced by traditional markets in the Sleman area amounting to 4740.63 kg/day. Sampling was conducted for eight consecutive days to determine the existing waste generation. The composition of vegetable and fruit waste dominated the waste generation results with 44%. To continue this research, good waste management is needed to reduce and suppress waste produced from traditional markets so that waste that was initially worthless becomes economically valuable.

Research entitled "Analysis of Factors Influencing the Implementation of Waste Management Policies in Yogyakarta Using Dynamic System Modeling," taken from a sociological analysis journal published by Gajah Mada University researched by Erpin Habibah, Febi Novianti, Hanafi Saputra in 2020 shows that waste management in Yogyakarta has not yet been implemented. surprisingly good. Factors that influence poor waste management in Yogyakarta include government policies that are not yet fully known, care about waste and public awareness is still low, and facilities at TPS are inadequate. Identify problems using a dynamic analysis system to find the root causes of poor waste management in Yogyakarta. This research stopped making a causal loop diagram to analyze waste management because, according to CLD researchers, it was enough to explain the root of the problem of the research conducted. Accumulations of waste will increase as the lack of understanding of waste management policies increases, in this case, there is a loop that is reinforcing (mutually reinforcing). Apart from that, there is a balancing loop where the availability of landfills is controlled by external factors, namely the number of residents, which will be inversely proportional to the number of landfills.

The next research, entitled “Dynamic System Model for Evaluating Waste Management Scenarios in Depok City” was taken from regional and environmental journals researched by Ika Artika and Mochammad Chaerul in 2020. This research was conducted by trying four scenarios to predict the level of waste management in Depok City from 2020 until 2045. The first scenario is to conduct a simulation with the waste handling carried out by the Depok city government as usual, known as the business-as-usual scenario, with a waste processing rate of 6.61% or 95.5 tons/day. Unprocessed waste is immediately disposed of at the Cipayung landfill. The second scenario was prepared with a focus on seeing the effect of optimizing existing waste processing facilities when the level of waste service reaches 100%. In this scenario, there are no additional waste management facilities. The third scenario was prepared with a focus on seeing how significant the reduction in waste to landfill would be if referring to the Jakstrada programs. In scenario B, it is assumed that there is a reduction in waste through EPR (extended producer responsibility) and the addition of BSU (waste bank unit). The fourth scenario was prepared with a focus on seeing how significant the reduction in waste to landfill would be if referring to the Jakstrada programs. In scenario B, it is assumed that there is a reduction in waste through EPR and additional BSU. In this scenario, it is assumed that there is a reduction in waste through EPR, the involvement of the private sector to manage its own waste, as well as the addition of BSU, UPS, and TPST. This research aims to assess which scenario produces the lowest value for waste transported to landfills, land requirements, waste management costs, and emission burden. This simulation was conducted using STELLA 9.1.3 software.

The research entitled “Decomposition Characteristics of Organic Solid Waste from Traditional Market by Black Soldier Fly Larvae” taken from the International Journal of Applied Engineering Research written by Priscilia Dana Mentari, Lia Nurulalia, Idat Galih Permana, and Arief Sabdo Yuwono in 2020 shows the percentage reduction in organic waste by BSF larvae around 41-63%. The FMCR (fresh matter consumption rate) obtained was 21-67 mg/larva/day. The identified survival rate is 15-100%. In terms of mass, the most significant was in the aggregate waste sample whose transformation reached 4.5 gr/20 individuals. In conclusion, the best sample decomposition process by BSF larvae is in aggregate form. The highest protein content in BSF, namely 36.39%, can be obtained from 12-day-old larvae. The quality of the compost resulting from decomposing traditional market organic waste for 30 days meets the compost quality standards regulated in SNI 19-7030-2004, except for the C/N ratio parameter. The total reduction in organic waste conducted by BSF supports this research as one of the composting technologies so that it produces which composting technique is appropriate for the highest waste reduction when a simulation is carried out for making decisions on reducing organic waste produced by the Tempel market.

Research conducted by Intan Permata Dewi, Muhammad Rizal Taufikurohman, and Noverdi Bross in 2021 with the title “Financial Feasibility Analysis of Making Animal Feed from Organic Kitchen Waste” published by the Journal of Agricultural Economics and Agribusiness (JEPA) volume 5, number 3(2021) resulted that the calculated value for analyzing the financial feasibility of the business obtained an R/C Ratio value of 2,257 and a B/C Ratio value of 1,237. BEP Volume obtained a value of 53.17 kg and BEP Price obtained a value of IDR 13,292. Payback Periods (PP) for the maggot cultivation business conducted by the BSF Dadali Maggot Activists Association experienced a return of capital within a period of 4 months and 9 days (5 periods), so it can be concluded that the cultivation business carried out by PPM BSF Dadali is feasible to run. This research shows that the calculation of maggot sales business analysis in terms of NPV, IRR, B/C, and PP can support this research to determine the feasibility of managing traditional market waste, which is most appropriate and has the greatest level of market organic waste reduction and produces value. highest economy. The impact of this research helps to determine the feasibility of an organic waste management business in the Tempel Sleman market using the BSF technique.

Research conducted by Dewi Diniaty, Jaka Prindra Divine, Wresni Angraini, Ekie Gilang Permata, and Silvia entitled “Techno-Economic Analysis of The Use of Waste as Material for Making Liquid Organic Fertilizer (Case Study: Pekanbaru Panam Tuesday Market)” resulted in a Cost of Production of Liquid Organic Fertilizer of 5,222/Liter. Then it can be offered to consumers with a margin of 16%, resulting in a selling price of IDR 6,000/liter. As an alternative liquid organic fertilizer, this is cheaper than the selling price of organic fertilizers currently circulating on the market. In this experiment, three samples were used, namely Sample A in the form of 2 kg fruit and vegetable waste, 200 gr fish waste, 2 liters coconut water, 400 ml brown sugar liquid, 50 ml EM4 bacteria, 2 yeast bacteria, 50 ml kefir whey bacteria. Sample B consists of 2 kg of fruit and vegetable waste, 200 gr of fish waste, 2 liters of coconut water, 400 ml of brown sugar, 100 ml of EM4 bacteria, 3 yeast bacteria, and 100 ml of kefir whey bacteria. Sample C consists of 2 kg of fruit and vegetable waste, 200 gr of fish waste, 2 liters of coconut water, 400 ml of brown sugar, 150 ml of EM4 bacteria, 4 yeast bacteria, and 150 ml of kefir whey bacteria. From all existing samples, 13.5 liters of liquid organic fertilizer can be produced. All research results show that the Break Even Point for creating a liquid organic fertilizer business requires 321 liters of organic fertilizer for a year and produces BEP within 71 days. This research shows that policies for managing organic waste still have extremely high potential and will also help to determine the appropriate scenario for managing organic waste in the Tempel Sleman market.

The research entitled “Making Liquid Organic Fertilizer and Compost from Household Organic Waste” researched by Mukhlis Rohmadi, Nurul Septian, and Pertiwi Adi Puji Astuti published in the journal Environmental Science in 2022 resulted in 5.5 liters of organic liquid fertilizer being produced from 10 kg of organic waste. and 19 cm3 Biogas, as well as residue in the form of compost fertilizer. Meanwhile, the 5 Kg waste variation produces 3 Kg Organic Liquid fertilizer. The resulting organic liquid fertilizer can provide optimum nutrition for stem growth in the test plants of kale, spinach, and mustard greens. The method of adding or providing nutrients to evaluate plants uses an infusion system. To produce optimal liquid fertilizer, it is best to blend the waste first and separate the vegetables and fruit. Implementing the process of providing nutrition with an infusion system can be applied to save time and avoid forgetting to add nutrients. This research can support data that will be used as a comparison with existing composting techniques.

“Management Of Market Organic Waste Using An Earthworm Reactor (Lumbricus rubellus) With The Continuous Flow Bin Method,” written by Mashur, Hunaepi, Kemas Usman, and Iwan Desimal in 2020 published by the Biology Scientific Journal of Processing Market Organic Waste as feeding (feed) and waste mixture household organics mixed with cow feces as bidding (media) using a Lumbricus Rubellus earthworm reactor with a modification to the Continuous Flow Bin model, is able to process organic waste four times its body weight per day with excecated production of 2.59 kg/nest box. The Continuous Flow Bin Reactor is a reactor in the form of a box made from boards/plywood with the size of one reactor unit being 60 x 45 x 50 cm and made with legs like a table. A hole is made in the side of the box, which is covered with wire mesh, and at the top of the box, a cover is also made of wire mesh so that predators cannot enter. The amount of organic waste that can be processed by earthworms (Lumbricus Rubellus) both as media and as feed is an average of 4.35 kg/nest box for 40 days of cultivation with a stocking density of 25 grams of earthworms/nest box. Based on the results of this research, it can be concluded that the ability of earthworms (Lumbricus Rubellus) to process organic market waste using the modified Continuous Flow Bin method can reach 4.35 times their body weight/day. Thus, processing waste using this method can be a complete solution to the problem of managing market organic waste.

Research conducted by Tomy Budi Kusuma in 2018 was entitled “Study of Market Organic Waste Processing Using the Continuous Flow Bin Vermicomposting Method with Test Parameters C/N, P, and K Content.” The experiment was conducted using the first reactor feeding ratio of 1.25: 7, the second reactor 1 .5: 7, and the third applied a ratio of 1.75: 7 with a reactor size of 120x100x96 cm using earthworms (Lumbricus rubellus). The waste used for this research is waste originating from the outboard market with the feeding ratio, as previously mentioned. The organic waste that can be reduced in this research using 100 reactor units is 5.8% or the equivalent of 175 kg every 3 days. The products that can be produced from this reactor are two types firstly Lumbricus rubellus earthworms and vermicas, which can be sold at a price of 60,000/kg for Lumbricus rubellus worms and vermicas for fertilizer mixtures for farmers at a price of 1,000/kg. The costs incurred for setting up a small-scale business using ten reactors and operational costs amount to IDR 2,771,100. In one month, it can produce 60 kg of Lumbricus rubellus worms and 84 kg of vermicas. The calculated profit for the first month of running the business is IDR 3,375,900 per month.

Research conducted by Ervan Hasan Harun and Jumiati Ilham entitled “Analysis of The Potential of Gorontalo City Central Market Organic Waste as Raw Material for Biogas Energy” published by the Journal of Electrical Energy Engineering, Telecommunication

Engineering, and Electronics Engineering in 2023 resulted in the city of Gorontalo has a waste generation percentage of 74. 23% vegetable waste, 17.12% fruit waste, and 8.65% fish and meat waste. This waste generation, if converted into biogas, can produce 838.60 m3 per month or the equivalent of 5,11584 kwh of electrical energy per month. The potential for this waste can be processed into Biogas and produce Biogas per week of 152.52 m3 from vegetable waste, 35.17 m3 from fruit waste, and 21.95 m3 from fish/meat waste, and a total of 209.65 m3 per week or 838.60 m3 in 1 (one) month. The electrical energy that can be produced from organic waste at the Gorontalo City Central Market on average per week is 1,278.84 kwh, or the equivalent of 4 x 1,278.84 kwh = 5,115.84 kwh per month. With the Gorontalo community's electrical energy needs being 66.1% of the installed load, the potential electrical energy of 5,115.84 kwh per month produced from Biogas can be utilized by electricity customers from the 450 VA load group as many as 30 customers.

Table 1. Past Research

No	Researcher Name	Title	Method
1	Iswadianto.,2018	STUDY OF GENERATION, COMPOSITION AND MANAGEMENT PLANNING OF MARKET WASTE (CASE STUDY IN THE MARKET AREA OF SLEMAN REGENCY, YOGYAKARTA)	-Observation and sampling SNI 19-3964-195
2	Habibah., E.et al., 2020	ANALYSIS OF FACTORS INFLUENCING THE IMPLEMENTATION OF WASTE MANAGEMENT POLICIES IN YOGYAKARTA USING DYNAMIC SYSTEM MODELING	-Dynamic analysis system
3.	Artika, I., & Chaerul, M., 2020	DYNAMIC SYSTEM MODEL FOR EVALUATING WASTE	-Dynamic analysis system

		MANAGEMENT SCENARIOS IN DEPOK CITY	-Stella software
4	Mentari,P,D., et al., 2020	DECOMPOSITION CHARACTERISTIC OF ORGANIC SOLID WASTE FROM TRADITIONAL MARKET BY BLACK SOLDIER FLY LARVAE	-Black Larva Soldier Composting -Kjeldahl
5	Dewi,I,P., et al., 2021	FINANCIAL FEASIBILITY ANALYSIS OF MAKING ANIMAL FEED FROM ORGANIC KITCHEN WASTE	-Black Larva Soldier Composting -Break Even Point Analysis -Net B/C Ratio
6	Diniaty,D., et al., 2022	ECONOMIC ANALYSIS OF THE USE OF WASTE AS MATERIAL FOR MAKING LIQUID ORGANIC FERTILIZER (CASE STUDY: PEKANBARU PANAM TUESDAY MARKET)	-Liquid Organic Fertilizer Composting -Break Even Point Analysis -Test Nutrient Level
7	Rohmadi,M., et al., 2022	MAKING LIQUID ORGANIC FERTILIZER AND COMPOST FROM HOUSEHOLD ORGANIC WASTE	-Anaerobic composting -Liquid Organic Fertilizer
8	Mashur., et al., 2020	MANAGEMENT OF MARKET ORGANIC WASTE USING AN EARTHWORM REACTOR (LUMBRICUS RUBELLUS) WITH THE CONTINUOUS FLOW BIN METHOD	-Continuous Flow Bin modified -One Way Classification -Multivariate Test

			- Earthworm Lumbricus Rubellus
9	Kusuma,T,B., 2018	STUDY OF MARKET ORGANIC WASTE PROCESSING USING THE CONTINUOUS FLOW BIN VERMICOMPOSTING METHOD WITH TEST PARAMETERS C/N, P AND K CONTENT.	- Reactor Continuous Flow Bin -Vermicomposting -Economic Feasibility Study
10	Harun, H.E., & Ilham, J.,2023	ANALYSIS OF THE POTENTIAL OF GORONTALO CITY CENTRAL MARKET ORGANIC WASTE AS RAW MATERIAL FOR BIOGAS ENERGY	- Mix method quantitative and qualitative

2.2 Theoretical Foundation

2.2.1 Overview of Traditional Waste

According to Malano in Andi, explained that traditional markets are a manifestation of the people's economy, the lower economy, and a place to depend on small and medium level economic actors. Traditional markets are the economic foundation of businesspeople, farmers, craftsmen, or other suppliers of goods. Millions of Indonesians still entrust the procurement of their daily needs to traditional markets that are synonymous with the lower middle class. (Feriyanto, 2011)

Sumintarsih stated in Feriyanto that a traditional market is an organization where buyers and sellers can interact directly and buy and sell. Traditional markets are places of buying and selling that illustrate the socio-culture of the community concerned; this is related to economics, technology, social structure, politics, and kinship. Buying and selling transactions occur directly and usually through a bargaining process. In addition, markets also have a role in cultural change and renewal. (Feriyanto, 2011)

The remains of daily activities of humans and/or nature in solid form are defined as waste according to Law No. 18 of 2008. Waste is divided into organic waste consisting of objects that decompose quickly and can be decomposed naturally, inorganic waste or dry waste that is difficult to decompose and special waste in the form of hazardous waste and construction waste. (Artika & Chaerul, 2020)

The amount of waste generated will determine the type and appropriate management system. The amount of waste generated in an area is influenced by several factors. The first factor is population, the amount of waste generation is directly proportional to the population. The higher the population in an area, the higher the amount of waste generated. The characteristics of settlements and the number of housing complexes in an area also influence the amount of waste generated. Settlement characteristics can be based on occupation and settlement activities. (Kharismawati, 2018)

Three waste problems include input, processing, and output. In the input part, waste experiences a continuous increase in the amount of production from time to time. In the processing part, there are limited human resources from both the community and the government in managing waste. While in the output section, there is a lack of optimization of the system applied in the final processing. (Habibah et al., 2020)

Waste management is a systematic, comprehensive, and sustainable activity that includes waste reduction and handling. The waste management system is regulated in Law No.18 of 2008. The purpose of waste management is to improve public health and environmental health and make waste a resource.

Traditional markets have potential that cannot be ignored, both economically and socially. The potentials possessed by traditional markets according to Himawan in Andi (Feriyanto, 2011) are as follows:

1. Economically, the market can support thousands of people or is an arena to fulfill the needs of life or a space for people's economic empowerment.
2. The market as a public space is an arena for forming socio-economic relations, in which values of mutual trust, respect, and empathy for others are built.
3. Naturally, the market builds a community of various social groups, ranging from large traders, small traders, street vendors, porters, and shoppers.

Thus, traditional markets can be interpreted as a meeting place for market actors such as traders, buyers, service providers, and others who build sustainable social relationships. The pattern of relationships between market actors consists of various interrelated roles, in addition to bargaining patterns, the exchange of goods and services, there is also a non-economic relationship, namely helping each other, which is not found in modern markets.

One of the biggest contributors to waste in life is traditional markets. Traditional markets are one of the most important public facilities and are needed by people in both cities and villages to fulfill various basic daily needs. People will not be able to escape from the market element because the level of public consumption is getting higher and more diverse. However, this is not in line with the condition of traditional markets, which are often considered a shabby and unpleasant-smelling place due to the waste produced every day. (Marlina et al., 2021) However, from some of the explanations above, traditional markets have several tasks that need to be addressed and improved, namely regarding waste management, which is increasing day by day, and in terms of management are still relatively minimal if left without handling and solutions, traditional waste will have a negative impact on the surrounding environment.

Waste generated by Traditional Markets comes from every market operational activity. Waste-generating areas include stall areas, stall areas, ground areas, yard areas, parking areas, warehouses, market management offices, prayer rooms, and bathrooms. Waste includes three types, namely: Solid Waste, Liquid Waste, and Waste in the form of Gas. Based on the substance and its formation Solid Waste (called garbage) is distinguished as organic waste and inorganic waste types of waste can be divided into several types, namely (Tiara Andriani, 2018):

1. Based on the chemical substances (properties) contained in them:
    a. Organic Waste is waste that can decompose, for example: food waste, leaves, vegetables, and fruit.
    b. Inorganic waste is waste that cannot decompose, for example, metal, glassware, ash, and others.
2. Based on whether it can be burned:
    a. Combustible waste such as plastic paper, dry leaves, wood, old cloth, etc.

b. Non-combustible waste such as cans, iron, broken glass, etc.

3. Based on Waste Characteristics
    a. Garbage consists of substances that easily decompose and can decompose quickly, the decay process often causes a foul odor. This type of impact can be found in residential areas, restaurants, hospitals, markets, and so on.
    b. Rubbish is divided into combustible rubbish consisting, for example, of organic substances, for example, paper, wood, rubber, and leaves.

2.2.2 Aspects of Traditional Market Waste Management

Waste management is expected not only for health purposes but also for the purpose of environmental cleanliness and beauty, as the waste management stage, which includes collection, transportation, destruction, or utilization of waste so that it does not interfere with the health and environment of the community around the traditional market. (Tiara Andriani, 2018)

Waste management is a series of structured, systematic, and comprehensive activities that include 5 (five) components, namely technical aspects, financing aspects, organizational aspects, legality aspects, and aspects of community participation (Law 18 of 2008, Damanhuri & Padmi, 2010). The waste management system is an interaction that occurs between various components that are interrelated with one another. The market is one of the city's waste service areas that must have access to waste services. Handling market waste management cannot be done by the market cleaning department alone. Waste management conducted within the market is only limited to the collection of waste at one temporary waste disposal (TPS) at the market location. The waste needs to be transported to the final disposal site (LANDFILL). Therefore, it is necessary to conduct waste management in an integrated manner and integrated with the city's waste management system. (Susilawati & Wahyono, 2019)

The waste management system consists of technical and non-technical aspects. Both aspects are mutually sustainable and need to be carried out in harmony to create a good waste management system. In urban waste management, there are five subsystems, namely

Operational Aspects, Legal and Regulatory Aspects, Financing Aspects, Institutional Aspects, and Community Participation Aspects (Kharismawati, 2018), namely:

A. Operational Technical Aspects

Operational Technical Aspects based on the Regulation of the Minister of Public Works of the Republic of Indonesia Number 03/PRT/M/2013 concerning the Implementation of Waste Infrastructure and Facilities in Handling Household Waste and Waste Similar to Household Waste include waste sorting activities, waste collection, waste transportation, waste processing, and final disposal of waste.

The operational aspect of waste management is the action on waste starting from containerization, collection, transportation, and processing to disposal. Actions against waste are conducted in an integrated manner with sorting from the source based on SNI 19- 3964-1994. Waste containerization and collection are calculated by calculating the ratio of the amount of waste collected and transportation time. Waste transportation can be optimized by calculating the maximum number of trips that can be done with existing infrastructure. Improving the quality of operational aspects is also influenced by the performance of managers and workers who have resources in related fields (Marlina et al., 2021), following the concept of waste management:

Figure 1. Concept of Waste Management

In the flow of waste management above, there is a management scheme that is tried to be applied using a dynamic model, namely waste management by composting, namely:

1. Waste Management with Recycle

   It is one of the solid waste management strategies that consists of sorting, collecting, processing, distributing, and manufacturing used products/materials. The recycling process is influenced by fractional factors (percentage) of sorting ability, delivery time and processing time. The nature of recycling is to delay the accumulation of inorganic waste, so eventually the result or product will become waste again.

2. Waste Management with Compost

   Waste treatment by composting is a way of accumulating waste in small pits for a certain period to produce natural fertilizer or decomposition process conducted by microorganisms on biodegradable organic waste. (Surjandari et al., 2009) Another alternative to composting is using composting from BSF flies which can be reused and has economic value.

B. Regulatory Aspects

Waste management is an activity that requires good planning and organization. Waste management in Sleman Regency is conducted by the waste section of the Environmental Agency, which is assisted by the Technical Implementation Unit. Both are regulated in Sleman regent regulations number 80 and 81 of 2016. The task of the Environmental Agency in the waste sector is to plan, conduct guidance, control management, development, and maintenance. The UPT is tasked with assisting the implementation and is responsible for the DLH. In one UPT, there is an organizational structure consisting of the head of the UPT, the Administration subdivision, and functional position groups.

Waste arises in tandem with human activities. Waste that is not managed will become a problem. To manage and control waste, the Indonesian government makes laws that regulate waste. Here are some of the regulations used to manage waste. There are several government regulations that regulate waste management in the Sleman area, namely:

1. Law No. 18 of 2008 on Waste Management System
2. SNI 19-2454 of 2002 concerning Operational Engineering Procedures for Urban Waste Management
3. SNI 3242-2008 About Procedures for Settlement Waste Management - SNI 19-3964-1994 About Methods of Taking and Measuring Examples of Urban Waste Generation and Composition

4. Regulation of the Minister of Public Works No. 3 of 2013 concerning the Implementation of Solid Waste Facilities and Infrastructure in Handling Household Waste and Waste of Household Type
5. Regulation of the Minister of Public Works No. 1 of 2014 concerning Minimum Service Standards in the Field of Public Works and Spatial Planning

The latest regulation used to measure the level of waste management achievement is Presidential Regulation No.97 of 2017 concerning National Policy and Strategy for Household Waste Management and Household Waste. The regulation also regulates the targets that must be achieved in waste management by 2025. Waste management, which consists of handling and reduction activities, is given a target of 30% and 70% of waste by 2025, respectively.

The implementation of market activities and market waste management must comply with all relevant regulations. These regulations contain policies and technical guidelines for implementation. Technical guidelines related to the regulations should be practical and directly applicable. The instructions must include specifications accompanied by clear descriptions that show that the process is safe and under applicable standards. (Marlina et al., 2021)

C. Institutional Aspects

The institutional aspect contains the parties that intervene in waste management. In waste management, institutions have roles as regulators, supervisors, coaches, controllers, assistants, and waste-handling parties. The formal institution of the government of Indonesia, which is the Department of Environment (DLH), plays the role of regulator, supervisor, and coach. Informal parties such as recyclers, community organizations, and scavengers have roles that can help run each aspect of management. In decentralized waste management, the effectiveness of waste management is influenced by the good relationship between the informal and formal sectors.

Specialized waste management training can make waste management practices correct and in accordance with applicable regulations. The training aims to improve the skills of market cleaners who can later make a good contribution and make the work done more efficiently, quickly, and on time, as well as reduce the frequency and cost of work accidents and assist market cleaners in improving and developing personal skills. (Marlina et al., 2021)

D. Financing Aspects

In the waste management system, financing is a key factor to support the success of the waste management process. In addition, financing is also closely related to the completeness of infrastructure for the waste management process and market hygiene programs. Financing waste management has a significant role in maintaining market waste facilities and infrastructure. Various waste management problems are caused by limited funds for equipment investment, operation funds, and maintenance of infrastructure facilities. Waste management cost requirements will increase as far as the level of service or volume of waste must be managed. Management institutions are required to be able to accurately plan funding needs every year so that waste management can run in accordance with the main objective, namely realizing a clean and healthy environment. (Marlina et al., 2021)

E. Aspects of Community Role

Community participation and the formal management system form a balance of behavior in the waste management system and do not confuse community participation with the role of formal institutions in management aspects. In a study in Xiamen, China, community participation in waste management was determined by several key factors. The delivery of useful information to the community responded positively to the level of participation. Other influential factors are social motivation, operational services, effective delivery facilities, and institutions. (Kharismawati, 2018)

The community has a vital role in waste management in the context of environmental protection and management. The role of the community can be in the form of social supervision, providing suggestions, opinions, proposals, objections, complaints, submitting information, and reporting. This community involvement is conducted to increase awareness of environmental protection and management.

According to Shalil in (Habibah et al., 2020) Socialization from the government side is also extremely low, and is not the policy made to overcome problems. If you look at the picture of the implementation flow, what the government thinks about is the technical handling of waste. Yet, the root cause of this imbalance is public awareness of waste management. The action that the government needs to take is how to build a waste-conscious mindset according to the technical design in the policies made. Future waste management strategies that need to be considered, such as:

1. Socialize the establishment of waste-free areas, such as tourist attractions, markets, hospitals, terminals, protocol roads, urban villages, and so on.
2. Providing facilitation, encouragement, assistance/advocacy to the community to improve waste management.

2.2.3 Waste Management Using Dynamic System Model

Dynamic system modeling is not only simple but also powerful because simple ideas can be combined into complex system models and processes. In addition, useful modeling makes modeling integration simple. It is natural because the simple ideas behind the dynamical system model correspond to the basic form of human thinking. Dynamic system modeling can help humans to see the system. (Yahya, 2018)

The dynamic model approach is deductive and can eliminate weaknesses in the assumptions made, and agreement on these assumptions can be obtained. The process of change from one condition to another is the main thing that is emphasized in a dynamic model.

Municipal solid waste (urban waste management system) is a problem because it has not been integrated. The way that is often done by the community is by burning in open spaces. These practices have a negative impact on the environment and are also socially unacceptable. Therefore, alternative options to the existing waste management system should be further investigated. (Aye & Widjaja, 2006).

The difference between household and market waste management is different, this is because household waste management is managed by informal institutions outside the government while market waste management is conducted by pre-determined officials and shows lower operational costs. (Aye & Widjaya, 2006) Therefore, market waste management may have fewer social barriers compared to household waste if managed privately. The implementation of a healthy integrated waste management system may require more effort and time to be successful in Indonesia as the education level of the public is low.

System dynamics models include a set of conceptual and numerical methods used to understand the structure and behavior of complex systems. A system dynamics model represents the causal relationships, feedback loops, and delays/constraints that are expected to result in system behavior. System dynamics is widely used to develop environmental models and decision support systems. The system dynamics methodology has four main principles, namely feedback control theory, the decision-making process, the use of mathematical models to simulate complex processes, and the use of computer-based technology to develop simulation models (Agustia, 2014).

A. Principles of Dynamic System Models

The principles of dynamic system models are as follows:

1. Elaboration is the gradual development of a model starting from a simple model until a more representative model is obtained.
2. Synectic is the development of a model that is done analogically (similarities)
3. Iterative is the iterative development of a model and revisiting it.

B. Stages of dynamic system modeling

Some of the things that need to be considered and prepared in applying the dynamic model in waste management in the Tempel traditional market are as follows: Dynamic Systems explain the modeling of problems that arise that have no known root cause. Sterman in (Habibah et al., 2020) explains in his book Business Dynamics that in modeling a dynamic system through several stages, namely:

1. Identify problems and data.
2. Create a Causal Loop Diagram (CLD).
3. Apply CLD to Stock and Flows Diagram (SFD).
4. Describe the root cause of the SFD obtained.

However, in this study, the researcher skipped the SFD stage, this is because the CLD was considered sufficient to explain the root of the problem.

C. Cost to profit

A development in waste management is to change the paradigm from financing to profit or means to gain profit. Thus, waste management must produce something useful not only to reduce the amount of waste to reduce water, air, and soil pollution but also to fulfill the needs of the community. Several waste processing methods can be developed to produce products that have selling value, namely composting, recycling, and waste to energy. (Surjandari et al., 2009)

This is in line with research conducted by Isti which resulted in a conclusion regarding the government's policy model on waste management Based on the results of the analysis, both with a dynamic system and AHP prioritization scale and Benefit-Cost ratio (B / C), it is recommended that waste management carried out by the DKI Jakarta local government be carried out in stages, first by composting. This is based on consideration of existing problems (pollution, rejection from the community, and so on), and consideration of each criterion from all aspects (especially the social aspect which has the greatest preference compared to other aspects, namely 53.8%), and also based on the feasibility of investment (B/C ratio of 1.41), as well as the factor of reducing the pile of waste which is quite high. The second is with an incinerator. Waste processing with incinerators can be carried out after socialization to the community, so that the potential for conflict can be reduced in addition to the potential for positive utilization both in terms of investment feasibility with a Benefit-Cost ratio (B/C) value greater than one (1.04) and the effectiveness of reducing waste piles (66%). (Surjandari et al., 2009)

D. Model Validation

Validation is an important process to build confidence in the model. Based on critical reviews, the test applies to dynamic system modeling (Agustia, 2014). Model validation is designed to compare whether the behavior of the model built for key variables can represent and represent the real conditions. This is important so that the model designed is valid or is a model that is a representation of the real system conditions being modeled. (Yahya, 2018) Some tests that must be passed by the dynamic system model are as follows:

1. Test 1 - Boundary test: does the model contain all variables that are important to the research problem?
2. Test 2 - Structure verification: is the model structure consistent with the descriptive knowledge relevant to the system being modeled?
3. Test 3 - Dimensional consistency: the model must be dimensionally/unitarily valid, i.e., the dimensions (units of measurement) of the variables on the right-hand side of each equation must be convertible to the dimensions of the variables on the left-hand side of the equation.
4. Test 4 - Extreme conditions: does the model exhibit the right behavior when subjected to extreme conditions?

The above test is not complete but has covered the core tests for dynamical system models. Therefore, these tests are applied to the dynamical system model developed in this study to improve the robustness and reliability of the model. Model validation can also be done by comparing the simulation results with the current situation. If the simulation results show a trend following the existing situation, the model can be considered appropriate, otherwise, it is necessary to make improvements to the simulation model. (Agustia, 2014)

CHAPTER III

RESEARCH METHODS

3.1 Object of Research

This research was conducted in Tempel Sleman Market. The object of this research is the management of organic waste in the Tempel market temporary disposal site. A dynamic system simulation model was created to determine the organic waste processing technique with the largest reduction for 5 years from 2023 - 2028 with monthly data results. The results of this simulation will be used as a decision to calculate the business feasibility analysis of organic waste processing techniques.

3.2. Data Type

3.2.1 Primary Data

Primary data is data obtained through interviews with the Integrated Service Unit (UPT) of the market in the Sleman District and the Sleman District Environmental Service as well as related data or reports for waste generation problems that occur at the research site. This data is managed to get the results of the amount of waste per month generated by Tempel Market where this research was held. The data presented from 2018 to 2022 is used as material for validation of the simulation and as a consideration for determining the right waste management policy.

3.2.2 Secondary Data

Secondary data is obtained from literature studies of various kinds of organic waste reduction with composting techniques, data derived from journals, articles, and books that support or have similar topics, especially in terms of organic waste management and analysis of the business feasibility of the composting techniques used so that they can support primary data.

3.3 Data Collection Method

The data collection methods used in this research are as follows:

1. Field Study

   Field studies are carried out by direct observation of the object of research. The following techniques are used to obtain data.

   a. Interview

      Interviews were conducted with experts, namely the Head of UPT market region II Sleman who oversees the Tempel market, and Dinas Lingkungan Hidup as the agency that provides data on waste generation and the section that deals with waste management in the Sleman District. This interview was conducted to ascertain the factors that influence the making of the model, as well as the evaluation of the model that has been made and was carried out by asking questions related to waste management. Interviews with the Head of UPT and DLH Sleman Regency consider the level of complexity of the model being made. Understanding the current waste management system is very well understood, it will have an impact on the validation of the model to be made and will facilitate model changes in the future.

   b. Data Documentation

      Data documentation is done by collecting the necessary data from the amount of waste generation, daily waste delivery to the Piyungan landfill, and the total stalls in the Tempel market.

2. Literature Study

   Literature study was conducted by collecting secondary data related to this research. The process was conducted by studying literature such as journals and books, which were then used as references in this research. The data obtained through this process are scientific insights related to waste management, dynamic systems, and business feasibility analysis of several organic waste processing techniques.

3.4 Data Processing Method

After obtaining the data needed in this study, the next step is to process the data. The following describes the data processing in this study.

3.4.1 Creation of Causal Loop Diagram (CLD)

Model conceptualization is done by creating a causal loop diagram. This diagram shows the direction of flow of variable changes and their polarity. The polarity of the flow is divided into two, namely positive and negative. Positive polarity here if the changes that occur in the variables at the beginning of the flow cause the variables at the end of the flow to change in the same direction. Meanwhile, negative polarity is when changes that occur in the variables at the beginning of the flow result in changes in the variables at the end of the flow in the opposite direction. The causal loop diagram that occurs in the current research object is described as follows:

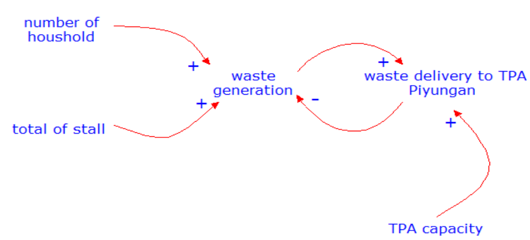

Figure 2. Casual Loop Diagram existing waste management at Tempel market

The object of research only collects waste from the market without any processing after which the total waste is sent to the Piyungan landfill. The lack of waste management from the Tempel market TPS will have an impact on the total waste in the Piyungan landfill, so it is necessary to organize waste management from the Tempel market TPS itself. The Causal Loop Diagram scenario for waste management at the TPS is made as follows:

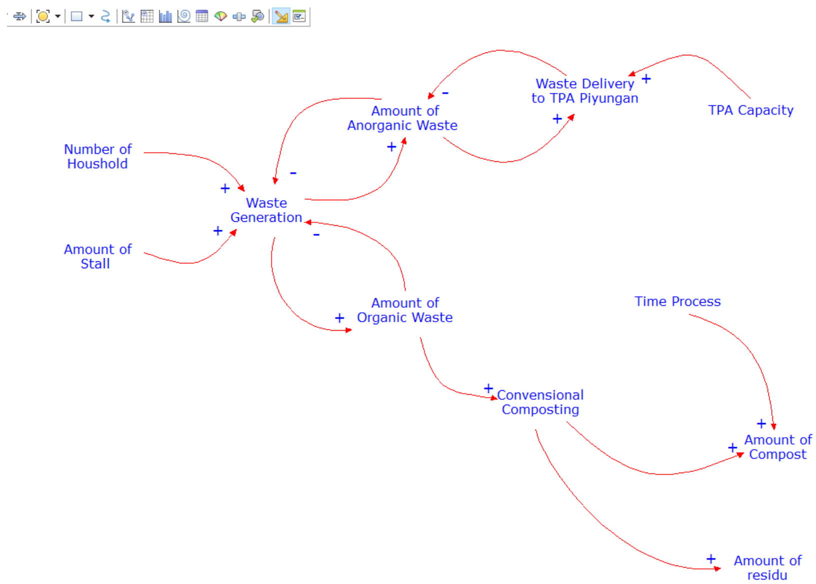

Figure 3. Scenario Casual Loop Diagram use Conventional composting.

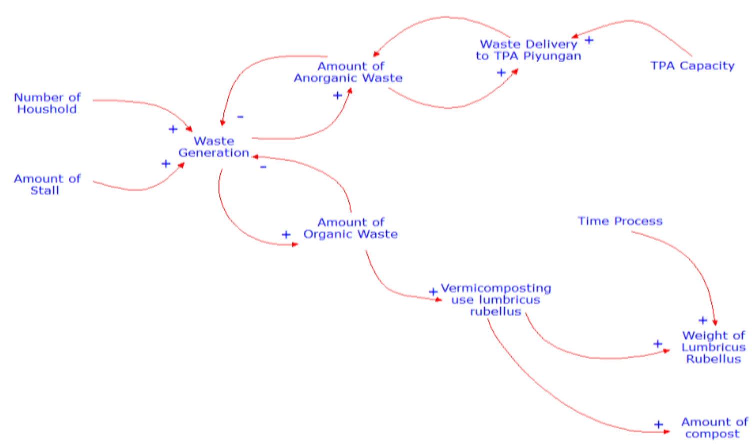

Figure 4. Scenario Casual Loop Diagram Use Vermicomposting with Lumbricus Rubellus

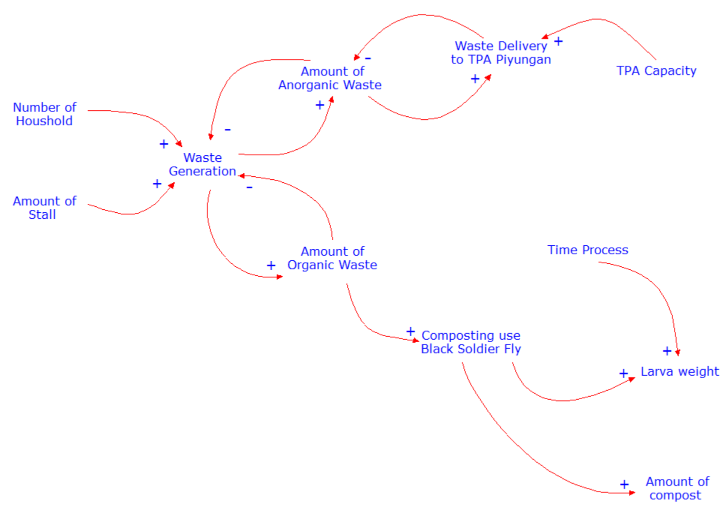

Figure 5. Scenario Casual Loop Diagram Use Composting with Black Soldier Fly

The limitation in this research is organic waste, so in the CLD above the changed variables are composting techniques for organic waste management.

3.4.2 Flow Diagram Modeling

Flow diagram modeling is done after CLD creation. The flow diagram is a development of the CLD model and defines its relationships and their respective values according to the real system.

3.4.3 Scenario Implementation and Improvement

The application of waste treatment scenarios in the Tempel market was conducted to identify which organic waste treatment technique can reduce waste the most. From the simulation results, the scenario with the greatest organic waste reduction was determined. Then, the selected scenario is used as the basis for scenario improvement and then a business feasibility analysis is carried out to obtain calculations and considerations for improving the existing system in the Tempel market so that waste that has no economic value can be processed for profit. The scenario implementation pattern can be seen in Figure.

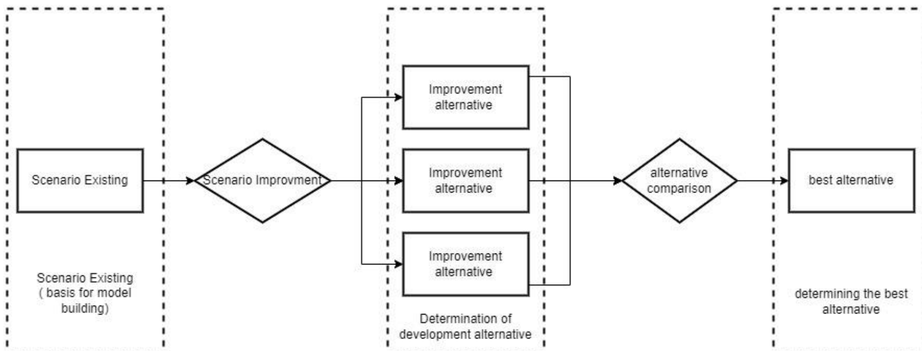

Figure 6. Diagram Implementing scenario.

3.5 Research Flow

In the figure below the flowchart of the research implementation along with an explanation of each stage of the research:

Figure 7. Research Flow

Based on the research flowchart above, several stages must be conducted. Starting from the problem identification stage to the stage where this research is considered complete. The following is a further explanation:

1. Problem Identification At this stage, it is determined which problems will be raised in the research so that it becomes a problem formulation. This problem formulation is done to facilitate the problem-solving process and achieve research objectives. Then, so that problem-solving can be more focused and not widened, problem boundaries are made.

2. Literature Review Aims to review various kinds of literature that can be used to determine the research method to be used. There are two kinds of literature review.
    a. Inductive study which contains previous studies that have a relationship with the research being conducted.
    b. Deductive study that contains the theories used in the research.
3. Data Collection Data collection is conducted in several ways to obtain the necessary data. Primary data was obtained through direct interviews with the UPT market region two, and the Sleman Regency Environmental Agency and the processing of the reports obtained. Meanwhile, secondary data was obtained through literature studies from previous studies.
4. Data Processing After the required data has been completed, the next step is to process the data. The stages conducted in data processing are as follows:
    a. Problem Identification and Definition At this stage, a situation analysis is carried out to see the actual system conditions. The results of the analysis will produce parameters related to the problem of waste management in the Tempel market as a basis for creating a Causal Loop Diagram (CLD).
    b. Model Conceptualization At this stage, a CLD is developed based on the identified parameters. CLD describes the relationship between parameters and the pattern of reciprocal relationships between parameters (Feedback Loop). The identification of relationships between variables is based on literature data from previous research, but if the relationship is not available, the relationship is based on expert views.
    c. Model Formulation Dynamic system simulation model formulation is based on variables, relationships between variables and conceptual models of the system. The model is formulated using Powersim software.
    d. Model simulation and validation the model that has been made before being used for analysis is first verified and validated. Verification aims to determine the

presence of errors in the model, while validation aims to test whether the model can represent actual problems.

e. Policy analysis and development in this section, an analysis of the behavior of the existing system based on the model is conducted. Furthermore, improvement scenarios are formulated, and a business feasibility analysis of the selected scenarios is also carried out.

CHAPTER IV

DATA COLLECTION AND PROCESSING

4.1 Design of Organic Waste Processing at Pasar Tempel Temporary Waste Disposal Site

Tempel market currently has no waste management, and workers only collect waste from the main and Tempel fruit markets daily. All waste is collected at the temporary waste disposal site at the Tempel fruit market. The collected waste is sent to the Piyungan landfill once a week. According to the manager, this shipment is also not certain every week because the manager also considers waste in markets throughout Sleman so that the delivery of waste to the Piyungan landfill is conducted according to the priority scale of the waste pile. The Tempel market temporary waste disposal site has the dimensions as shown in the image below:

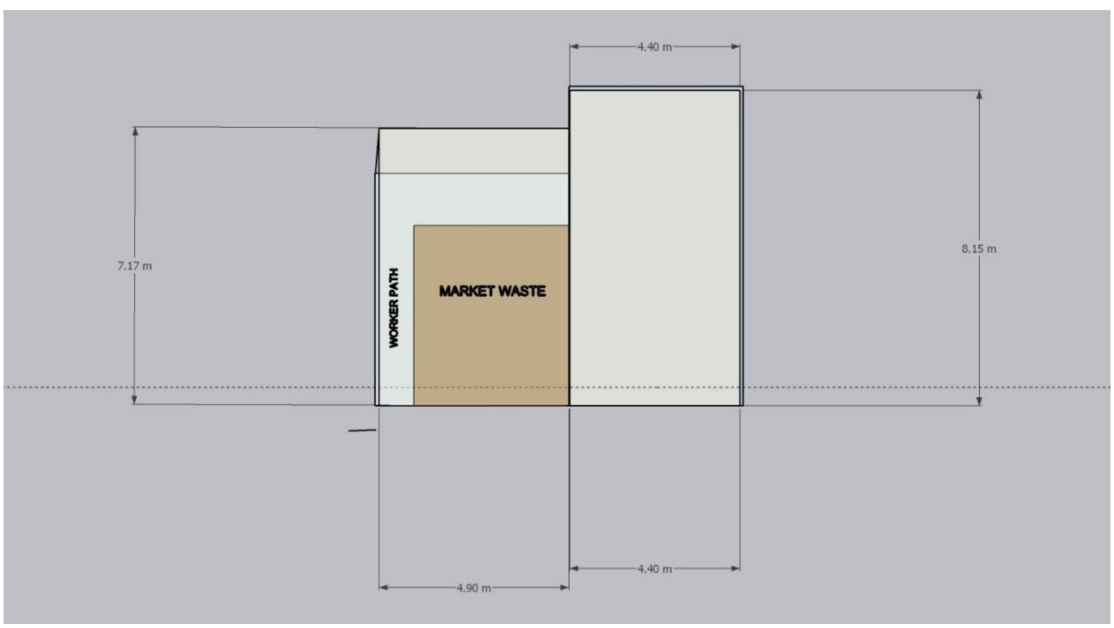

Figure 8. Layout Temporary Waste Disposal Site

The initial layout of the temple market without any waste management impacts the piles of waste in the temple fruit market. This situation causes the temporary waste disposal site to produce an unpleasant odor, and this causes flies to roam and breed in the existing piles of garbage. Tempel market also does not segregate organic and inorganic waste, so the existing waste is mixed with the market waste in Figure 8 above. Tempel market temporary waste disposal site layout as shown above without waste management. Accumulation occurs because there is no waste management. Waste that has accumulated will be picked up by the manager once a week. With the temporary waste disposal site size as in the picture above, the proposal for processing organic waste using Black Larva Soldier would be as follows.

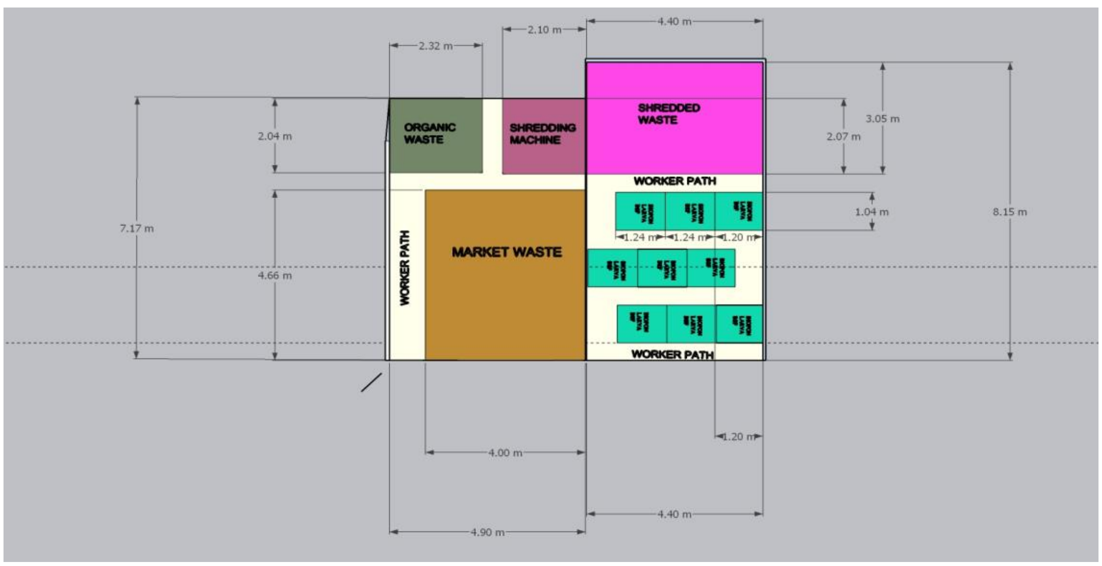

Figure 9. Layout Improvement Using Larva BSF

With the proposed waste management, the layout of the temporary waste disposal in the Tempel market will be as shown in Figure 9. This proposal provides room for the organic waste shredding machine and a specific area for organic waste to make it easier for workers to shred it. The shredded organic waste is collected in the shredded waste area to facilitate the distribution of waste for processing by BSF larvae. The BSF larvae rack is design to make it easier for workers to distribute organic waste to the BSF larvae development rack. This processing design can accommodate 450 grams of BSF larvae eggs. Each shelf can accommodate fifty grams of maggot eggs. According to previous research by Nursaid et al. (2019), 3 grams of maggot eggs can produce approximately 26,000 individuals, so when we get it, every 1 gram of maggot eggs can produce approximately 8,500 individuals. So, one shelf can produce 425,000 maggots. With the proposed design, there are nine maggot development shelves. With this design, the outboard market temporary waste disposal site can accommodate the rearing of 3,825,000 maggots. Previous research stated that the average weight of one maggot is 2.26 mg. By feeding organic waste at 100 mg/larva/day, one shelf can reduce organic waste by 42,500,000 mg (42.5kg organic waste) in one day. To meet the needs of nine maggot shelves, 382.5 kg of organic waste is needed daily. By feeding maggots at 100 mg/day/larva, the final biomass of maggots on day nineteen after feeding is 81 mg/head. So, in one maggot development rack, it is expected to get 34,425,000 mg (34,425 kg) of maggots, and with the proposed 9-rack design, it is hoped to get a total of 309,825 kg of maggots. The BSF larva development biopond reduces larval predators such as chickens, rats, and lizards. The management does not enlarge the larvae into black soldier flies, so every 21 days, the management needs to re-order BSF eggs. Organic fertilizer produced from the remaining digestive process of BSF larvae co, called frass, can be harvested simultaneously as maggots. The distance between ordering BSF eggs and the hatching time of BSF eggs can be used to harvest fertilizer and the BSF larvae themselves. So once this cycle occurs, the processing time is one month. The design of the maggot enlargement rack is as shown in the following picture:

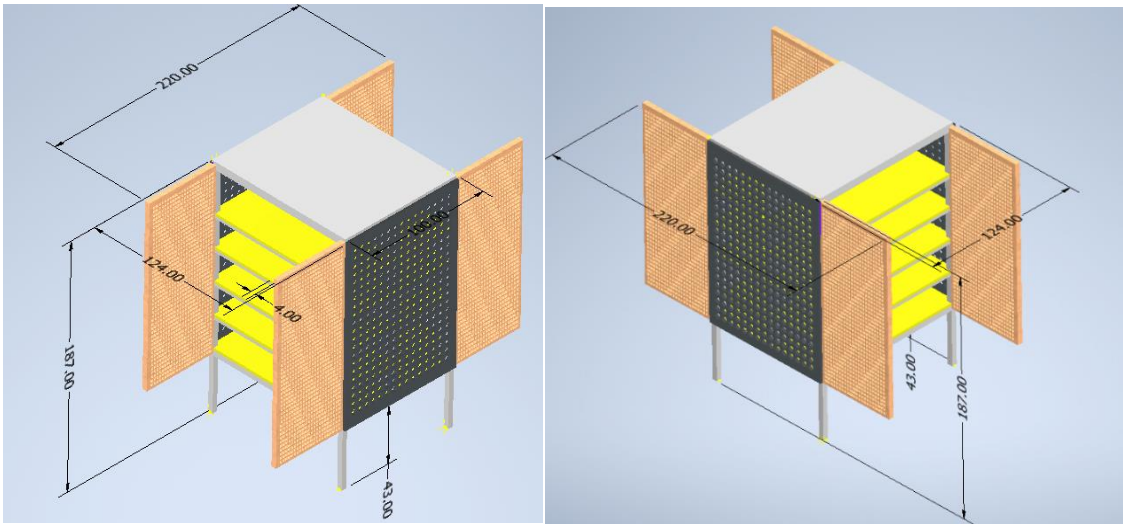

Figure 10. Desain Rack larvae-rearing BSF

This rack design can accommodate 10 BSF larvae-rearing ponds. The development biopond will use a conventional container with type 6688 and a size of 100x33x19 cm. Galvalum hollow iron with a 3 x 3 cm diameter is used as the main frame material. This material is lightweight, does not easily corrode, and has a sturdy structure. The cage material uses insect net material on the cage wall because insect net is a material that has strong durability if placed outdoors, has a small hole diameter to prevent insects from outside entering, and still maintains air circulation in the cage and a combination of zinc roof and transparent polycarbonate on the roof material because, during rainy conditions, water does not enter the cage and during hot weather sunlight can still enter the cage. The size of this development rack totals 124x126x187 cm when closed and becomes 124x220x187 when the door is opened during maggot feeding. Each biopond accommodates five grams of Black larva Soldier Fly egg. One rack can accommodate fifty grams of larva egg.

The second organic waste management method uses earthworms (Lumbricus rubellus). In this process, the location design for the Pasar Tempel temporary waste disposal site will be as follows.

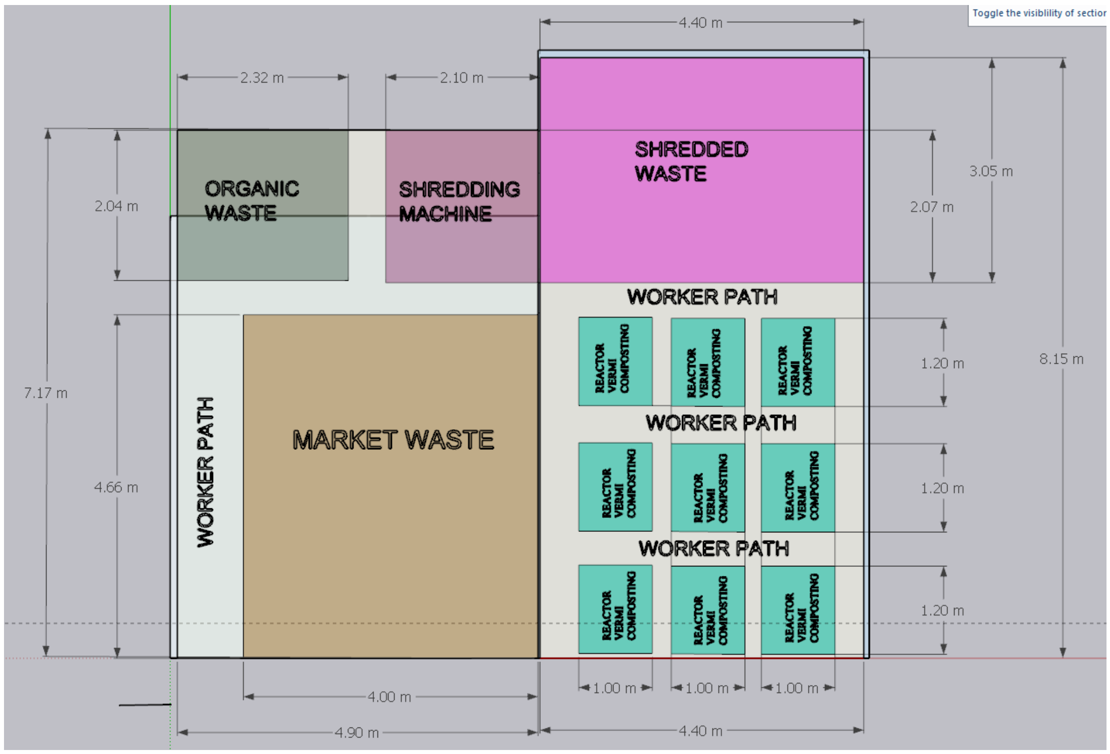

Figure 11. Layout Improvement Using Lumbricus Rubellus

Another layout of waste management uses BSF larvae with earthworms, Lumbricus rubellus. The proposed design using lumbricus earthworms is like the layout of the BSF larvae development. Due to the difference in the size of the development rack using BSF larvae and earthworms, there is a change in the layout of the development rack. In this proposed layout, a special road is also provided for workers to facilitate the distribution of chopped organic waste. Figure 11 proposed layouts for waste management at the outboard market. This design can provide space for organic waste that has been chopped using a chopping machine. Space for chopped organic waste is placed at the back to make it easier for workers to feed the Lumbricus rubellus earthworms. There are nine earthworm development shelves. Moreover, on each shelf are two biopond for developing Lumbricus rubellus earthworms. The design of the vermicomposting and biopond shelves is as shown in the picture below:

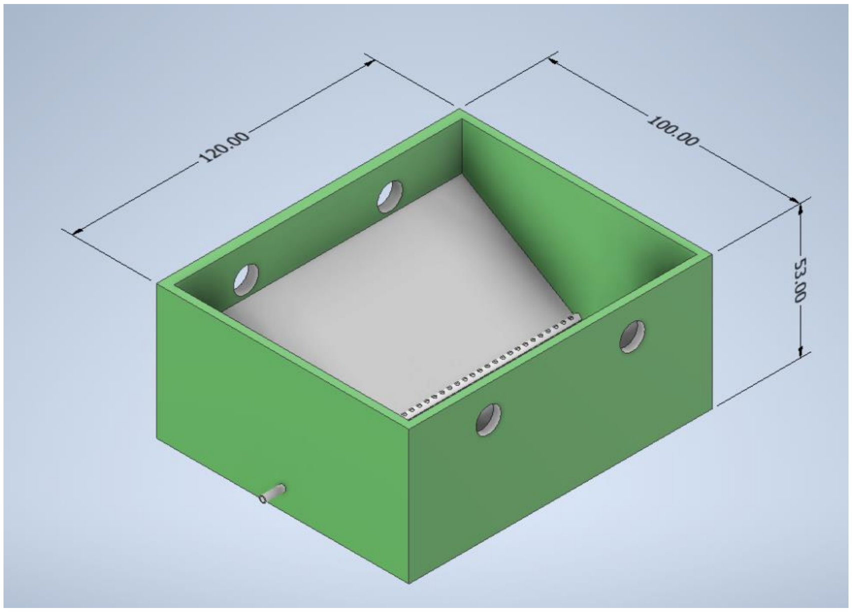

Figure 12. Biopond Lumbricus Rubellus

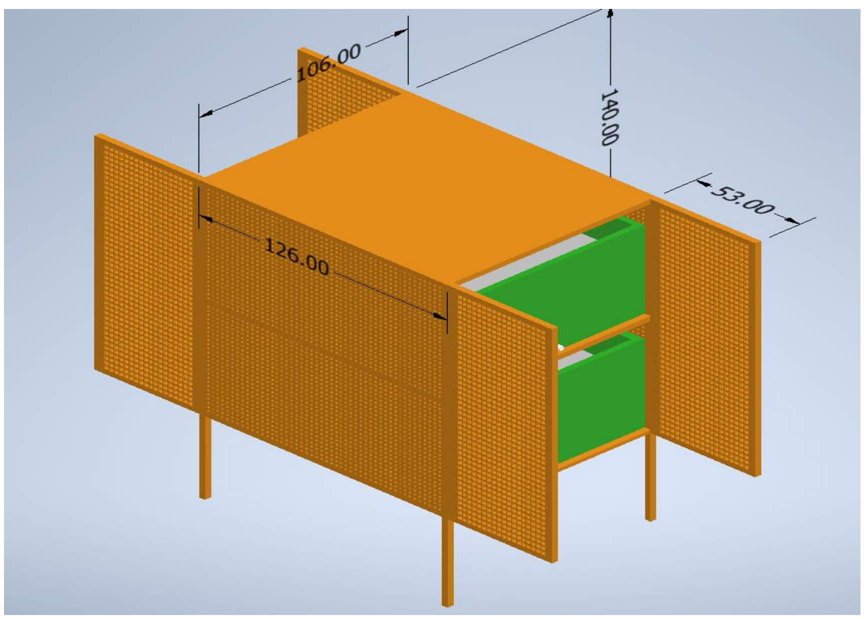

Figure 13. Rack Lumbricus rubellus Rearing.

In this design, we use a 1:10 ratio with the layout design. The Autodesk Inventor application is used to make it easier to create this design. The material of this shelf uses stainless steel, thereby reducing the risk of Lumbricus rubellus earthworm pests such as mice, ants, and chickens. Air circulation is also a consideration in the design of this shelf so that the shelf is not closed tightly but uses a perforated iron net. At the bottom of the shelf, an ¾ inch-diameter pipe is provided and filled with water so ants cannot crawl up. A net measuring 2.8cm x 1.5cm can also prevent mice from entering the vermicomposting shelf. In the biopond for developing earthworms, there are two layers. The first layer is small gravel to make it easier for water from organic waste to go down to reduce air pollution caused by organic waste. Each shelf can accommodate 4,000 (4kg) grams of worms by feeding organic waste every three days with a feed weight of 1.75 kg. This proposed layout can accommodate nine shelves, so the total capacity for earthworms is 36,000 (36kg). These earthworms will be harvested in 30 days. According to research by Kusuma.,T.,B (2018), feeding 17.5 kg/3 days can increase the weight of earthworms to 10,000 grams (10 kg/rack), so with a 9-rack design, it becomes 90 kg of earthworms. Earthworms, which help decompose organic waste, can be used as fish feed. Apart from producing earthworms, this process also produces vermicast, which is good for the soil and can also be called organic fertilizer. This biopond design can also protect earthworms from predators or existing pests such as mice, millipedes, snakes, land frogs, centipedes, cockroaches, ants, ducks, chickens, birds, snakes, and lizards. The place where the biopond is placed is also designed to make it easier for workers to feed and harvest earthworms themselves.

4.2 Model Preparation

4.2.1 Causal Loop Diagram

In making the CLD, brainstorming, and observations were conducted to determine the variables influencing existing waste generation and management in the Tempel market. Interviews were conducted with the Sleman Region 2 integrated service unit head and the Department of Industry and Trade to obtain the required data. The software used in making the CLD is PowerSim Studio 9.0. The following are the variables used in CLD in the Business-as-usual scenario:

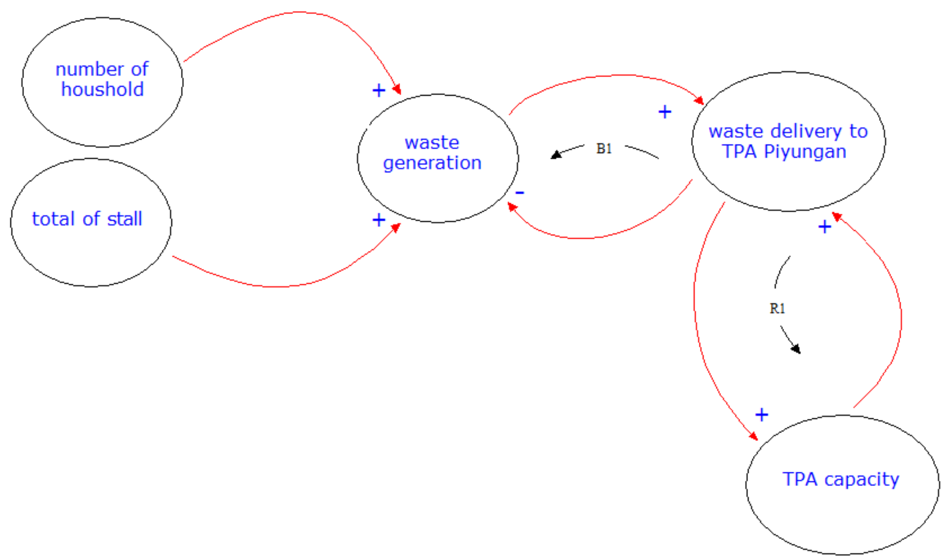

Figure 14. Business-as-usual Casual Loop Diagram

This causal loop diagram design was obtained after communicating with market managers and observations that had been made. The waste generated at the outboard market temporary waste disposal site comes from residents and traders at the outboard market itself. The variable number of households and total stalls add to the waste generation at the outboard market temporary waste disposal site. The balancing loop occurs when variable waste is delivered to the Piyungan landfill through waste generation. By sending waste to the Piyungan landfill, the amount of waste in the outboard market temporary waste disposal site is reduced, and the more waste there is at the outboard market temporary waste disposal site, the more waste needs to be sent to the Piyungan landfill. The reinforcing loop occurs with Piyungan landfill capacity because the more the Piyungan landfill can accommodate waste, the higher the amount of waste sent to the Piyungan landfill, so a reinforcing loop occurs in this model.

After that, by identifying the problems at the Tempel Market temporary waste disposal site, it is necessary to model a new scenario to reduce the amount of waste at the Tempel Market temporary waste disposal site. The proposed new scenario causal loop diagram is as follows:

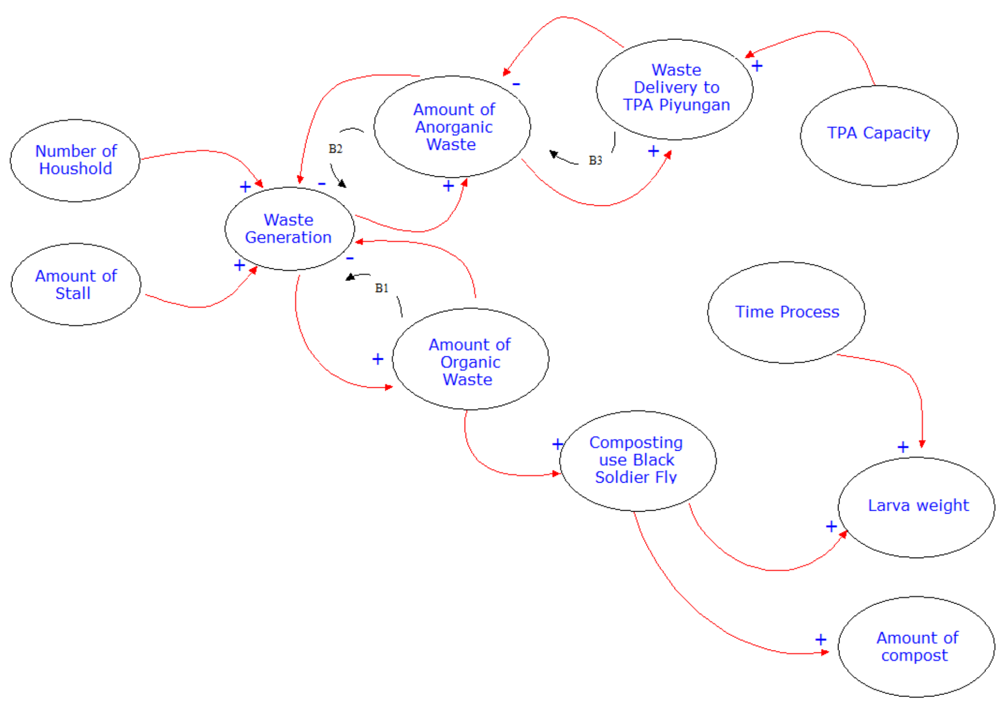

Figure 15. Larva BSF improvement Casual Loop Diagram

CLD improving this scenario that eventually can reduce the total organic waste at the Tempel market temporary waste disposal site. Improving the scenario using black soldier fly larvae can reduce waste generation at the outboard market temporary waste disposal site. In improving this scenario, the focus is still on reducing organic waste, and the scenario for reducing inorganic waste has yet to be improved. B1 shows the balancing loop interaction between waste generation and the amount of organic waste. The more organic waste, the more waste generation will be reduced in the outboard market due to independent organic waste management. The B2 Balancing loop occurs when inorganic waste reduces the amount of waste generation at the outboard market landfill by sending inorganic waste to the Piyungan landfill. B3 balancing loop occurs in the amount of inorganic waste with waste delivery to the Piyungan landfill. The more inorganic waste will increase the level of waste delivery itself, and the higher the delivery routine, the less inorganic waste there will be at the outboard market landfill. The second CLD improvement scenario using the Lumbricus rubellus earthworm method can be seen in the picture below:

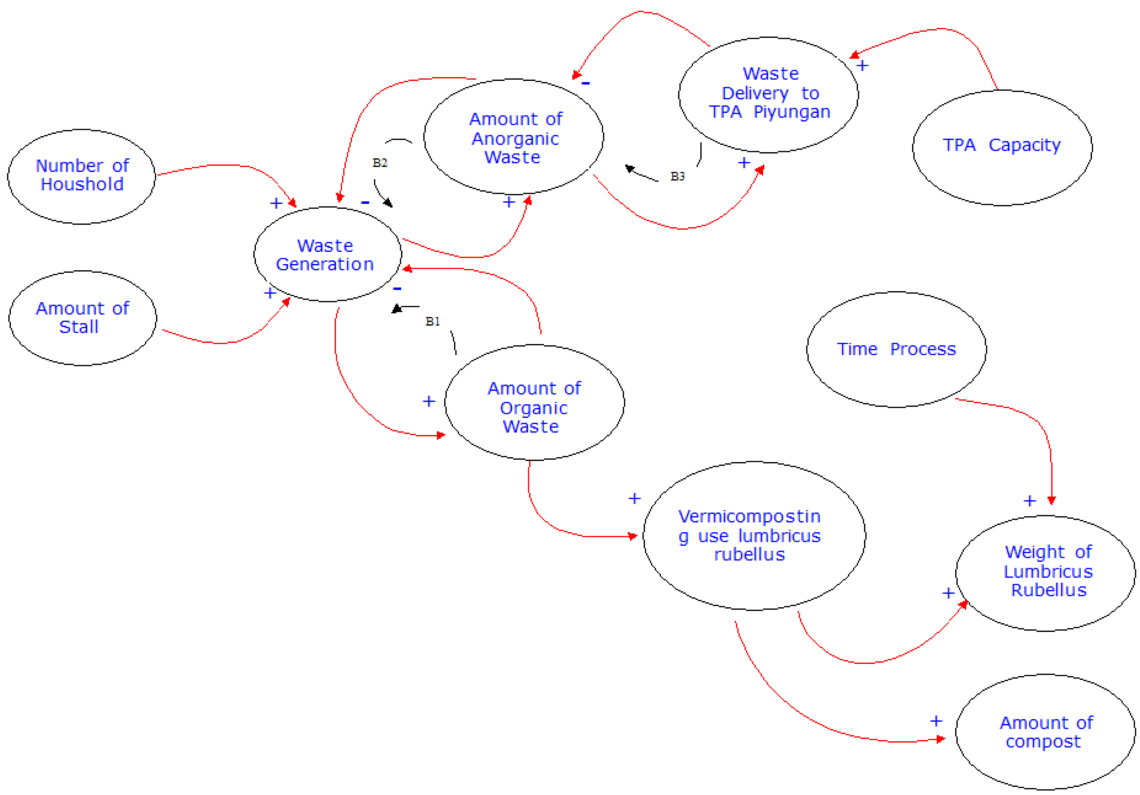

Figure 16. Lumbricus rubellus improvement Casual Loop Diagram

The difference in the CLD improvement scenario using earthworms and black soldier fly larvae is the amount of organic waste reduced by these two methods. The balancing loop in this scenario is not too different from the improvements in the previous scenario. The proposed reduction amount is written in sub-chapter 4.1.

4.2.2 Identify variables.

Identifying variables that influence the waste management system is one of the stages of system conceptualization. The purpose of variable identification is to deepen understanding of the system to be modelled. In the business-as-usual scenario, the table displays the variables that support our understanding of the system:

Table 2. Identify Variable

No	Variables	Measurements
1	The population of Lumbungrejo	Person
2	Number of traders	person/Mo
3	Waste generation from traders	kg/Mo
4	Waste generation per person	kg/Mo
5	Garbage at the market landfill	kg
6	Landfill waste generation	kg
7	Garbage sent	kg/Mo
8	Piyungan landfill capacity	kg
9	Trader's rubbish per day	kg/Mo
10	Trash per person	kg/Mo

11	Residents who go to the market every day	person/Mo
12	People going to the market	%
13	The average potential population goes to the market	%
14	The number of residents potentially going to the market	person/Mo
15	Number of relatives	person/Mo
16	Number of families in one family	person
17	Population death	person/Mo
18	Death rate	%/Mo
19	Population birth	person/Mo
20	Birth rate	%/Mo
21	Weight of organic waste	kg/Mo
22	Weight of inorganic waste	kg/Mo
23	Total organic waste	kg
24	Total inorganic waste	kg
25	Total unmanaged waste	kg
26	Waste managed by BSF larvae	kg/Mo
27	BSF larvae feeding	kg/Mo

28	Total waste reduction by BSF larvae	kg
29	Compost fertilizer from BSF larvae	kg
30	Organic waste residue	kg
31	Waste digested by BSF larvae	kg
32	Percentage of BSF larvae feed consumption	%
33	Garbage that eaten by BSF larvae	kg
34	Maggot Eggs hatched in one biopond	grams
35	Number of larvae per one gram of eggs	larva/Mo
36	Number of BSF larvae in one biopond	larva/Mo
37	Number of BSF larvae in one rack	larva/Mo
38	Number of bioponds in one rack	10 units
39	Maggots are born in one life cycle	larva/Mo
40	Total shelves available	9 units
41	BSF larval population	larva/Mo
42	Harvest BSF larvae	larva
43	Weight of earthworms per head	kg/head
44	Weight of earthworms in one biopond	kg

45	Number of earthworms in one biopond	Worm
46	number of earthworms in one rack	worm
47	number of earthworms biopονds in one rack	2 units
48	Number of worms in one management cycle	worm
49	total rack of earthworms in one harvest	9 units
50	Earthworm population	Worm /Mo
51	Earthworms ready to harvest	worm
52	Harvest earthworms	worm
53	Average weight of earthworms after rearing	kg
54	Earthworms that are ready to harvest	kg*worm
55	Harvest earthworms	kg*worm
56	Waste digested by earthworms	kg
57	Earthworm compost	kg
58	Waste managed by earthworms	kg/Mo
59	Garbage that eaten by earthworms	kg

4.2.3 Modelling using Powersim.

System modeling in Powersim Studio is useful for obtaining simulation results of waste generation at Tempel market landfills and total waste reduction with the proposed model. The simulation was conducted for five years, from 2020 to 2025. Figure 11 modeling for Business as usual, Figure 12 scenario improvement modeling using BSF larvae, and Figure 13 scenario improvement modeling using the Lumbricus rubellus earthworm. The limitation in improving the scenario focuses on organic waste without making efforts to reduce the generation of inorganic waste.

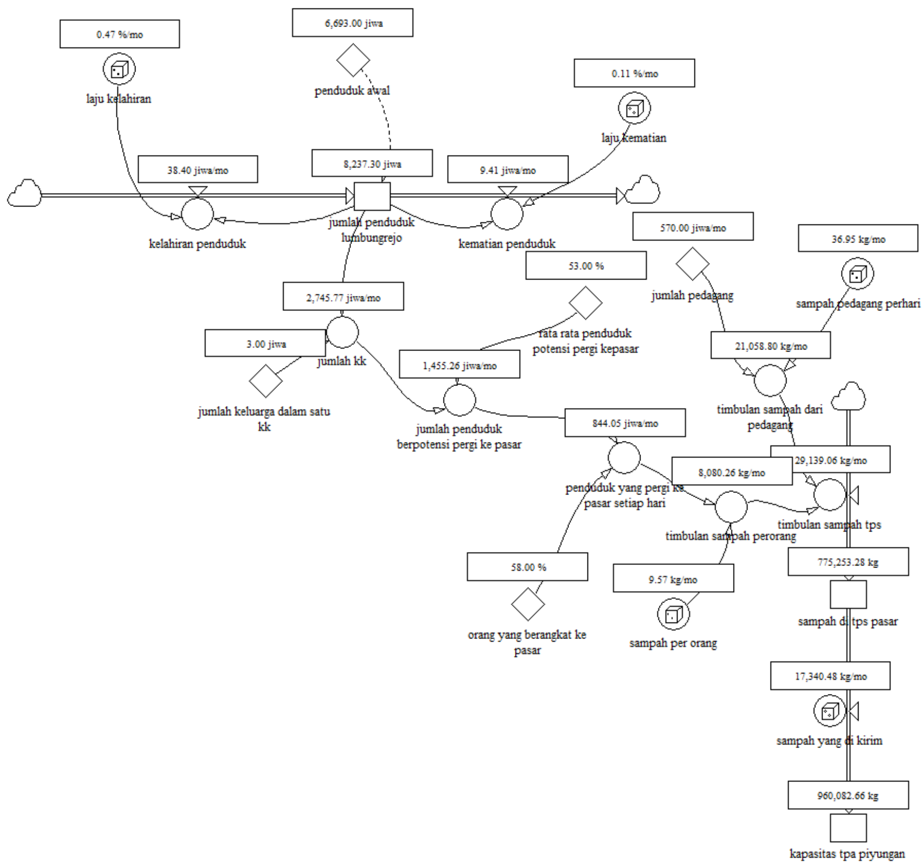

Figure 17. Business as usual Model in Powersim

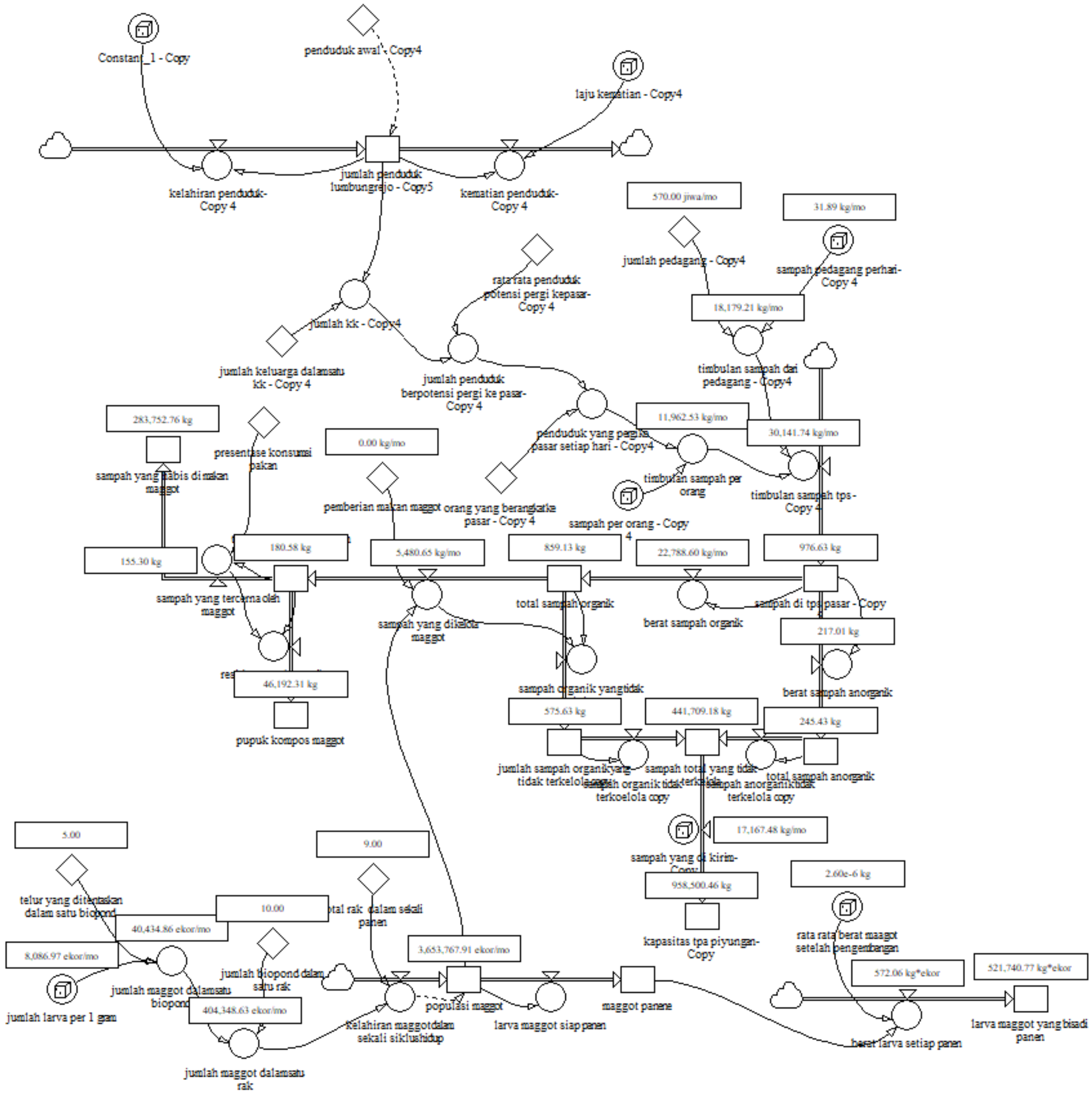

Figure 18. Larva BSF improvement model in Powersim

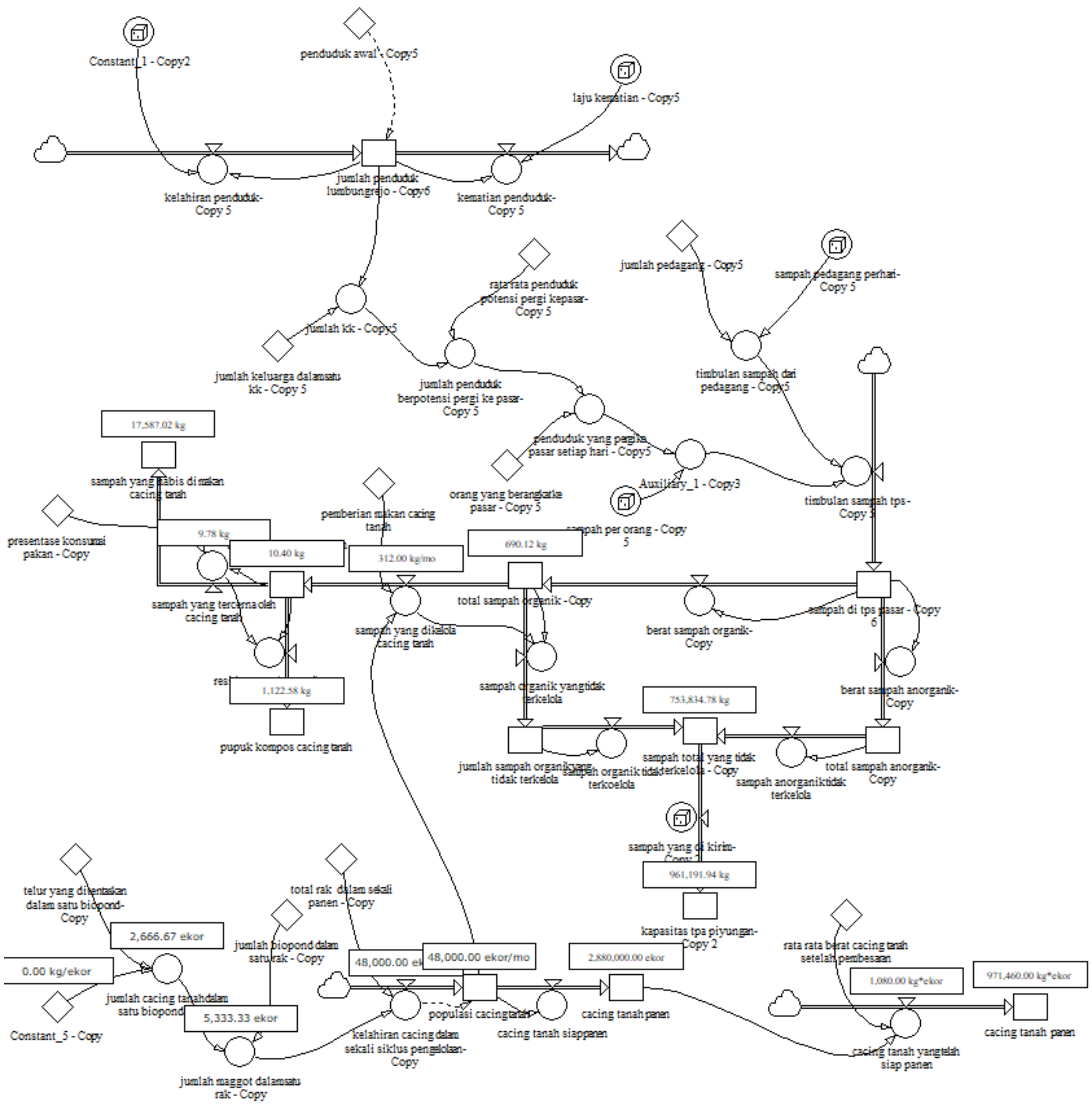

Figure 19. Lumbricus rubellus improvement model in Powersim

The Business-as-usual simulation at the Outboard market shows that the waste generated at the Outboard market amounts to 775,253.28 kg in the next five years. In the absence of waste management at the Tempel Market, there will be a buildup of waste at the Tempel Market temporary waste disposal site. The additions at the Piyungan landfill were also abundant, with a total additional waste of 960,082.66kg. The numbers from each model will change because the birth rate, death rate, waste generation from traders, and waste per person use random values obtained from journals and previous news.

In repairs using BSF larvae within five years, the waste provided by the Tempel Market would be reduced to 329,788.71kg. On the other hand, by improving this scenario, the management can also produce new products like BSF larvae that are ready for harvest, which can be used as feed for fish and other livestock. Furthermore, it will also produce compost weighing 46,170.42kg. Moreover, the maggot larvae that can be harvested are 518,165.54kg. Each model run will produce different values due to uncertain numbers, such as the number of hatched BSF larvae. The BSF larvae that drip every month are sometimes different. Previous research also stated that the BSF larvae range shows a rate of reduction and increase each time the process is repeated with uncertain values, making the scenario modeling closer to the real situation.

4.3 Simulation Results

After the system modeling in the Powersim application is complete, the simulation can be run. The parameters observed here are the population in Lumbungrejo and the waste generation in the Tempel Sleman market. The total waste in the Sleman outboard market can also be seen from the waste generation from activities at the outboard market. The amount of waste in the Sleman outboard market is not used as the main parameter due to the absence of original data. In the future, conducting separate research on this matter will be necessary.

Furthermore, data for waste generation parameters has been taken for seven consecutive days. With the seven days of data, synthetic data generation was created. The simulation results can be seen in the image below:

Time	sampah di tps pasar (kg)	timbulan sampah tps (kg/mo)	sampah yang di kirim (kg/mo)
Jan 1, 2021	0.00	25,906.59	14,364.63
Feb 1, 2021	11,681.42	27,558.51	12,436.69
Mar 1, 2021	24,015.10	28,366.31	19,650.54
Apr 1, 2021	35,836.71	26,491.65	18,017.24
May 1, 2021	47,753.63	28,935.84	14,661.23
Jun 1, 2021	59,946.52	27,449.97	15,308.38
Jul 1, 2021	71,437.40	25,576.21	12,340.89
Aug 1, 2021	83,218.91	28,222.85	19,801.76
Sep 1, 2021	95,906.06	29,985.71	15,808.60
Oct 1, 2021	108,656.00	30,503.88	12,977.06
Nov 1, 2021	121,251.15	28,577.45	18,503.51
Dec 1, 2021	133,819.89	25,309.11	12,828.16
Jan 1, 2022	146,660.09	28,904.06	16,023.33
Feb 1, 2022	159,770.09	25,342.01	19,596.84
Mar 1, 2022	172,020.40	28,957.87	16,711.78
Apr 1, 2022	184,799.56	25,051.85	17,781.98
May 1, 2022	197,235.77	28,595.36	19,197.10
Jun 1, 2022	209,714.90	29,860.96	19,076.72
Jul 1, 2022	221,599.94	29,611.63	14,801.34
Aug 1, 2022	233,613.93	26,085.76	12,959.38
Sep 1, 2022	246,043.99	28,331.78	13,845.56
Oct 1, 2022	258,764.90	26,066.18	12,874.09
Nov 1, 2022	271,718.41	31,982.46	17,353.15
Dec 1, 2022	284,935.62	29,281.96	18,503.24
Jan 1, 2023	297,926.64	28,328.78	19,974.23
Feb 1, 2023	310,253.98	27,820.00	16,669.53
Mar 1, 2023	323,701.38	24,175.90	19,693.10
Apr 1, 2023	335,504.05	31,912.67	17,847.99
May 1, 2023	348,927.85	25,331.41	18,820.54
Jun 1, 2023	361,465.01	28,607.58	12,390.41
Jul 1, 2023	374,570.70	30,098.09	13,744.73
Aug 1, 2023	387,843.10	26,636.69	12,973.31
Sep 1, 2023	401,618.95	32,219.76	15,047.16
Oct 1, 2023	414,979.42	29,313.75	18,461.13
Nov 1, 2023	427,830.63	29,932.58	16,922.59
Dec 1, 2023	441,428.80	30,572.60	16,872.66
Jan 1, 2024	454,659.81	28,071.83	18,718.85
Feb 1, 2024	469,283.70	33,211.14	14,308.86
Mar 1, 2024	482,014.18	31,622.43	13,557.33
Apr 1, 2024	495,841.24	24,503.95	14,771.37
May 1, 2024	508,630.48	31,471.31	13,920.84
Jun 1, 2024	521,820.97	31,156.91	16,085.48
Jul 1, 2024	535,482.54	29,178.72	14,653.66

Aug 1, 2023	387,843.10	26,636.69	12,973.31
Sep 1, 2023	401,618.95	32,219.76	15,047.16
Oct 1, 2023	414,979.42	29,313.75	18,461.13
Nov 1, 2023	427,830.63	29,932.58	16,922.59
Dec 1, 2023	441,428.80	30,572.60	16,872.66
Jan 1, 2024	454,659.81	28,071.83	18,718.85
Feb 1, 2024	469,283.70	33,211.14	14,308.86
Mar 1, 2024	482,014.18	31,622.43	13,557.33
Apr 1, 2024	495,841.24	24,503.95	14,771.37
May 1, 2024	508,630.48	31,471.31	13,920.84
Jun 1, 2024	521,820.97	31,156.91	16,085.48
Jul 1, 2024	535,482.54	29,178.72	14,653.66

Aug 1, 2024	548,546.49	27,410.52	15,198.93
Sep 1, 2024	561,677.92	29,688.86	19,841.70
Oct 1, 2024	575,874.36	29,569.75	17,248.79
Nov 1, 2024	589,389.45	28,280.22	17,392.28
Dec 1, 2024	602,963.79	32,337.77	18,817.64
Jan 1, 2025	616,259.96	28,806.68	12,134.26
Feb 1, 2025	630,145.44	30,377.86	17,440.80
Mar 1, 2025	643,767.87	28,011.12	18,012.98
Apr 1, 2025	656,735.32	27,764.73	12,507.12
May 1, 2025	670,643.29	30,659.86	12,956.36
Jun 1, 2025	683,901.35	32,909.10	16,874.54
Jul 1, 2025	697,353.92	30,383.99	17,285.37
Aug 1, 2025	711,231.19	26,613.28	19,936.53
Sep 1, 2025	724,704.55	26,231.10	18,121.16
Oct 1, 2025	737,924.06	29,878.88	16,705.38
Nov 1, 2025	752,584.58	32,955.62	15,759.58
Dec 1, 2025	766,136.58	30,789.80	16,273.01
Jan 1, 2026	780,658.26	31,015.12	12,789.18

Figure 20. Amount of Data Waste Generation After Simulation

From the simulation results image above, the lowest waste generation is 24,175.90 kg/month and the highest is 33,211.14 kg/month. In the fifth year after the simulation, business is as usual, and waste accumulation at the temporary disposal waste site Pasar Tempel is still at 780,685.26 kg. Waste reduction occurs when waste is delivered to the Piyungan landfill once a week, reducing it by 960,481.30 kg. Pasar Tempel can produce around 1,741,166 kg of waste within five years. The BSF larvae improvement scenario can reduce organic waste in the temple market temporary disposal waste site by 329,944 kg within five years. Therefore, the reduction would impact the accumulation of waste in the temple market, which became 441,709 kg within five years. The improvement shows that it can reduce waste in the Tempel market by 42%. The improved scenario using earthworm Lumbricus rubellus can reduce waste in the Tempel market by 18,706 kg within five years.

4.4 Model Validation

Because monthly population data is not available in the Lumbungrejo sub-district, data interpolation is required to obtain monthly data using the formula. After the formula has been implemented, the population data will be similar to following table:

Table 3. Interpolation Data Population in Lumbungrejo

Time	Data	Time	Data	Time	Data
1/1/2021	6694	1/1/2022	6732	1/1/2023	6778
2/1/2021	6696	2/1/2022	6736	2/1/2023	6781
3/1/2021	6698	3/1/2022	6740	3/1/2023	6785
4/1/2021	6700	4/1/2022	6744	4/1/2023	6789
5/1/2021	6702	5/1/2022	6748	5/1/2023	6792
6/1/2021	6704	6/1/2022	6752	6/1/2023	6796
7/1/2021	6706	7/1/2022	6756	7/1/2023	6799
8/1/2021	6708	8/1/2022	6761	8/1/2023	6803

9/1/2021	6710	9/1/2022	6765	9/1/2023	6806
10/1/2021	6712	10/1/2022	6769	10/1/2023	6810
11/1/2021	6714	11/1/2022	6773	11/1/2023	6814
12/1/2021	6716	12/1/2022	6777	12/1/2023	6817

Interpolation is needed to determine the population of the Lumbungrejo sub-district every month during the year 2021-2023. After modeling the data in Powersim, we can calculate the MAPE for the population in the Lumbungrejo sub-district. According to Lewis (1982), interpretation of MAPE values below 10% indicates very accurate modeling results, 10%–20% indicates good modeling results, 20%–50% indicates reasonable modeling results, and above 50% indicates inappropriate modeling results. The following table displays both actual data and data derived from modeling the Lumbungrejo population.

Table 4. Population Validation Test Use MAPE

Month	**Interpolate Data**	**Simulation Data**	**error**	**ABS**	
1	6694	6693	1	1	7.98864E-05
2	6696	6716	-20	20	0.003046153
3	6698	6738	-40	40	0.006020955
4	6700	6762	-62	62	0.009292438
5	6702	6785	-83	83	0.012412687
6	6704	6807	-103	103	0.015381842
7	6706	6830	-124	124	0.018498287
8	6708	6853	-145	145	0.021612808
9	6710	6876	-166	166	0.024725408
10	6712	6900	-188	188	0.027985073
11	6714	6925	-211	211	0.031391665
12	6716	6949	-233	233	0.034647267

13	6732	6972	-240	240	0.035699235
14	6736	6996	-260	260	0.038629092
15	6740	7020	-280	280	0.041555368
16	6744	7045	-301	301	0.04462635
17	6748	7071	-323	323	0.047841772
18	6752	7095	-343	343	0.050757075
19	6756	7119	-363	363	0.053668825
20	6761	7114	-353	353	0.05228741
21	6765	7168	-403	403	0.059629517
22	6769	7193	-424	424	0.062678292
23	6773	7217	-444	444	0.065575712
24	6777	7240	-463	463	0.068322052
25	6778	7266	-488	488	0.072042673
26	6781	7291	-510	510	0.075160598
27	6785	7317	-532	532	0.078422602
28	6789	7343	-554	554	0.08168115
29	6792	7369	-577	577	0.084936246
30	6796	7395	-599	599	0.088187897
31	6799	7422	-623	623	0.09158318
32	6803	7448	-645	645	0.094827877
33	6806	7474	-668	668	0.098069144
34	6810	7500	-690	690	0.101306986
35	6814	7526	-712	712	0.10454141
36	6817	7551	-734	734	0.107625735
				total	1.904750665
				MAPE	0.0529097407

				Percent error	5.3%

The table above shows data for the human population in Lumbungrejo. For the population in question, the MAPE value is 5.3 %. In this way, the modelling created indicates that the simulation results are very accurate. The outboard market lacks data on daily waste generation, necessitating the use of additional sources. Additional data was obtained using the Excel application, generating a random number between each entry. Random between uses the basis of taking a 7-day waste generation study obtained by taking it for seven consecutive days with the following results:

Table 5. Synthetic Data Generation Waste Generation

Month	**Synthetic Generate Data**	**Month**	**Synthetic Generate Data**	**Month**	**Synthetic Generate Data**
1	23952.409	13	23483.098	25	24238.46
2	23312.005	14	23762.952	26	23644.129
3	24682.141	15	24044.419	27	23296.267
4	23828.641	16	23668.939	28	23494.96
5	23601.85	17	23667.126	29	23218.778
6	23763.539	18	23944.224	30	24152.617
7	23639.929	19	23534.366	31	23533.626
8	23942.152	20	24031.474	32	23602.204
9	24225.068	21	23083.598	33	23197.992
10	23969.841	22	24177.044	34	24163.388
11	23856.996	23	24234.962	35	24097.441
12	23470.037	24	24093.827	36	24005.046

Next, data needs to be collected over a period of 3 years, specifically 36 months as shown in the table in the appendix. 3 Once obtain the random data results, a normality test using the SPSS application must be performed. A normality test is needed to see whether Synthetic Data Generation is distributed normally so that it can be used as a basis for data that is not available. The image of the data process in the SPSS application is as follows:

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
VAR00001	.104	36	.200*	.978	36	.671

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Figure 21. SPSS Result Synthetic Data Generation

The normality test yields a value of 0.2, surpassing the 0.05 threshold, indicating that the synthesized data follows a normal distribution pattern. Therefore, the synthesized data can be used for testing purposes. After that, the data modelled using Powersim must be validated using MAPE. The table below shows the validity of the test using MAPE:

Table 6. Validate Data Waste Generation Use MAPE

Month	**Synthetic Generate Data**	**Simulation Data**	**error**	**ABS**	
1	23952.41	25906.59	-1954	1954	0.081586
2	23312.01	27558.51	-4247	4247	0.18216
3	24682.14	28366.31	-3684	3684	0.149265
4	23828.64	26491.65	-2663	2663	0.111757
5	23601.85	28935.84	-5334	5334	0.225999
6	23763.54	27449.97	-3686	3686	0.15513
7	23639.93	25576.21	-1936	1936	0.081907

8	23942.15	28222.85	-4281	4281	0.178793
9	24225.07	29985.71	-5761	5761	0.237797
10	23969.84	30503.88	-6534	6534	0.272594
11	23857.00	28577.45	-4720	4720	0.197865
12	23470.04	25309.11	-1839	1839	0.078358
13	23483.10	28904.06	-5421	5421	0.230845
14	23762.95	25342.01	-1579	1579	0.06645
15	24044.42	28957.87	-4913	4913	0.204349
16	23668.94	25051.85	-1383	1383	0.058427
17	23667.13	28595.36	-4928	4928	0.208231
18	23944.22	29860.96	-5917	5917	0.247105
19	23534.37	29611.63	-6077	6077	0.258229
20	24031.47	26085.76	-2054	2054	0.085483
21	23083.60	28331.78	-5248	5248	0.227355
22	24177.04	26066.18	-1889	1889	0.078138
23	24234.96	31982.46	-7747	7747	0.319683
24	24093.83	29281.96	-5188	5188	0.21533
25	24238.46	28328.78	-4090	4090	0.168753
26	23644.13	27820.00	-4176	4176	0.176613
27	23296.27	24175.90	-880	880	0.037758
28	23494.96	31912.67	-8418	8418	0.358277
29	23218.78	25331.41	-2113	2113	0.090988
30	24152.62	28607.58	-4455	4455	0.18445
31	23533.63	30098.09	-6564	6564	0.27894
32	23602.20	26636.69	-3034	3034	0.128568
33	23197.99	32219.76	-9022	9022	0.388903

34	24163.39	29313.75	-5150	5150	0.213148
35	24097.44	29932.58	-5835	5835	0.242148
36	24005.05	30572.60	-6568	6568	0.27359
				total	6.694973
				MAPE	0.1859715
				Percent error	18.5%

The data validation conducted above yielded an error rate of 18.5%. Therefore, the current simulation results can be classified as a dependable model. Two model simulations resulting the MAPE in a dependable model so the simulation can be used for the base on the calculation in the future. This should be improved in more detail when the actual data for the waste organization is available. Besides that, the manager has confirmed the veracity of this model.

CHAPTER V

RESULT AND DISCUSSION

5.1 Initial Model Analysis

Based on dynamic simulations using the help of the Powersim studio 9 application that has been carried out, the variables that are the reference in this research are the variables of the population of Lumbungrejo, the waste generation at the Tempel market temporary waste disposal and the total waste at the Tempel market temporary waste disposal. From the simulation, the waste generation data in the Tempel market is at 24,175.90 Kg/month, and the highest is 33,221.14 Kg/month. There is a significant difference in waste generation because the waste generated by sellers and residents is not stable according to Chaerul.M., Dewi.T., P. (2020) research shows that each type of trader can produce diverse waste, so the types of traders in Tempel market are not all in this study. So, the data that has been taken needs to be processed again. This data processing shows that the waste generation from Tempel market traders ranges from 1 -1.32 Kg/month/seller in the temple market. Randomizing data would impact the results of waste generation in the temple market itself. So, the total waste generation varies every month, And the waste generation of people/day is also very varied. As reported by the Indonesian Ministry of Environment and Forestry, the amount of waste generation per person per day is 0.3-0.5 kg/day. Randomized data waste generation per person also impacts the simulation results.

With the simulation results and data validation using MAPE, it is found that the error rate in the total population in Lumbungrejo is at 5.3%; this shows that the simulation for the population in Lumbungrejo can be said to be fully accurate. For waste generation in the Tempel market, sampling was done for seven days to get data that was unavailable from the manager. Because we need more extensive data, we need synthetic generation data. After this data generation, a normality test is conducted. The normality test shows that the data is normal and can be used for the validation test of the waste generation simulation. After the validity test using MAPE, the error rate results were 18.5%, and the modelling for waste generation data was good. With this validity test, the simulation results show no significant difference between the model and the actual system.

Without waste management, there will be a significant accumulation of waste in the temple market and temporary waste disposal, negatively impacting the residents around the market and the management. This loss occurs because every waste disposal and delivery to the Piyungan landfill costs money. This modelling differs from previous research because it focuses on organic waste and specific methods. With the impact of waste accumulation, there is a need for a new management design in the temple market itself so that the temple market can turn waste that is considered to have no economic value into something of financial value.

5.2 Analysis of Scenario Improvements

The scenario improvement design was conducted to add consideration to the temple market management to improve existing waste management. Of the two improvement scenarios, organic waste reduction using larvae can reduce the accumulation of waste in the temple market by 42% compared to the business-as-usual situation. Meanwhile, waste reduction using the earthworm Lumbricus rubellus minimizes the accumulation of waste in the temple market by only 2.4%. Shows that adding the waste management process will reduce the waste pile in the temple market and facilitate temporary waste disposal. If the management wants to focus on waste reduction, using BSF larvae is recommended for the Temple Sleman market for temporary waste disposal.

In addition to reducing the accumulation of waste at the Tempel market temporary waste disposal itself, the management can also issue new products in the form of live BSF larvae ready for sale. Live BSF larvae are often used by poultry and fish farmers to substitute conventional feed. Sleman has fish and poultry farmers, so selling BSF larvae is simple. However, it is necessary to re-test the nutritional content of the harvested larva BSF at temporary waste disposal in the future.

5.3 Business Feasibility Analysis of BSF Larvae

With the existing simulation results, the simulation is said to be good. So, scenario improvements can already be used to write this business feasibility analysis. With the simulation results after five years, the total production of BSF larvae in the outboard market is 177,022 kg. And the monthly production is 2,950 kg. The calculation of business feasibility needs to be done to determine whether the BSF larvae development project is profitable and as an additional consideration for the manager in deciding waste management in the temple market.

Investment costs are fixed costs not affected by the number of products produced. The investment needs to be spent to realize waste management with BSF larvae of Rp 68,250,000 consisting of investment in production equipment and supporting equipment. Production equipment includes an organic waste chopping machine, BSF larvae development rack and biopond where larvae BSF are developed. While supporting equipment such as buckets for feeding, labor and maggot eggs that will be hatched. The investment table can be seen as follows:

Table 7. Initial Investment Production Equipment

No	Investment	Amount	Unit	Price	Total Price
1	Maggot development rack 1.2x1x 1.85 m	9	Unit	4,500,000	40,500,000
2	Container Box serial 6688	90	Unit	125,000	11,250,000
3	Shredding machine serial MPO 500 HD	1	Unit	16,500,000	16,500,000
Total					68,250,000

Table 8. Monthly Investment

No	Investment	Amount	Unit	Price	Total Price
1	Worker	2	People	1,500,000	3,000,000
2	Larva BSF Egg	450	Gram	3,000	1,350,000
3	Fuel	60	Liter	10,000	600,000
Total					4,950,000

With a projected one-month larval production of 2,950 kg. The projected output of BSF larvae refers to the simulation results using the Powersim application, where the total production of BSF temporary waste disposal Piyungan larvae in 5 years is 177,022 kg. The average selling price in the marketplace is 45,000 per kilogram. Then, the projection will be as follows:

Table 9. Projection Income

Year	2021	2022	2023	2024	2025
Larva BSF egg	16,200,000	16,200,000	16,200,000	16,200,000	16,200,000
Fuel	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000
Worker	36,000,000	36,000,000	36,000,000	36,000,000	36,000,000
Total expense	59,400,000	59,400,000	59,400,000	59,400,000	59,400,000
Income	132,750,000	132,750,000	132,750,000	132,750,000	132,750,000
Net profit	73,350,000	73,350,000	73,350,000	73,350,000	73,350,000

5.3.1 Payback Period

A payback period measures how quickly an investment can be recovered. The PP value is calculated by comparing the initial investment cost with the net benefits of a project in one unit of time. With the calculation formula investment / net profit x 1 year. To produce the following calculation:

PP = investment / net profit x 1 year

PP = 73,050,000/73,350,000 x 1 year

PP = 0.9 years

The results of calculations using the pp method show that the pp value is 0.9 years or equal to 11 months. So, the return on investment in this BSF larva project is 11 months. This business is feasible because the payback period of the business investment is less than one year.

5.3.2 Net present value (NPV)

NPV is based on the difference between the benefits and the cost plus the investment. With the formula present value benefit - present value cost. To produce the following calculation:

NPV = present value benefit - present value cost

NPV = 73,050,00 - 73,350,000

NPV = 300,000

Based on the business feasibility assessment calculation, this project is feasible. With an NPV> 0, which is 300,000, the NPV is positive and feasible.

5.3.3 Profitability Index (PI)

The profitability index is the ratio between cash flow and investment made. Calculation of profitability index = net cash flow value/investment value x 100%. With the following calculation:

PI = 73,350,000 / 70,050,000 x 100%

PI = 1.1

From the results of calculations using the PI method, it is known that the PI value is 1.1, so it gets a decent value because it is known that the PI value is> 1. This value indicates that this investment can be feasible to run.

5.4 Implication Managerial

In the implementation, waste management in the Tempel market will be improved. The manager is expected to make several policies so that the proposed scenario can run optimally and maximally. The policy of adding special garbage cans for organic and inorganic waste is expected to be distributed around the market area. It is expected to be distributed around the market area. This special trash can aim to collect garbage by workers, not mixing. So that the separation of organic and inorganic waste occurs before the waste enters the Tempel market temporary waste disposal site. Separating waste early on can structure organic and inorganic waste in an organized manner.

Market management also needs to hold the socialization of waste sorting awareness to provide additional insight to the traders and consumers who come to the market. Traders and consumers come so that they can overcome waste segregation from the beginning. From the beginning, waste is made. Making attractive designs for garbage will increase interest in disposing of organic and inorganic waste in the place provided. According to Sulistiyowati, A. Sugiarti, R. (2021), the application of rewards will have an impact on motivation to do an activity because people will feel more appreciated when they are because people will feel more valued when an activity that is done is given a reward, but these activities carried out are given a reward, but this must be done by the guidelines that the manager has previously compiled. Giving rewards to traders who deposit organic and inorganic waste is expected to increase the community's enthusiasm to sort waste from the start. Socialization and the provision of facilities must be conducted in stages to add insight and education to related parties involved in the community and educate related parties involved in the Tempel market.

CHAPTER VI.

CONCLUSION AND SUGGESTION

6.1 Conclusion

The following are conclusions on this research, based on the collection and processing of data that has been conducted data that has been done:

1. The simulation results using Powersim studio 9 show the accumulation of waste in the Temporary Waste Disposal Tempel market. The cause of this accumulation is that Business as usual in the Tempel market only relies on sending waste to the Piyungan landfill. This delivery is done in only a few weeks due to prioritization by the Temple market management. At the end of the simulation, the accumulated and unmanaged waste in the Tempel market amounted to 775,253.28 kg within five years of simulation.
2. Based on the simulation results using Power Sim Studio 9, waste management using BSF larvae can reduce the temporary waste disposal waste pile in the Tempel market by 329,788.71kg. This reduction is greater than the proposed waste management using earthworms Lumbricus rubellus. This reduction in the waste pile will reduce the impact of the waste pile itself.
3. Waste management using BSF larvae can be a new business income for Tempel market management. Organic waste that previously had no value can be processed and become a new product in the form of BSF larvae and organic fertilizer that can be used for animal feed and sold. This way, waste that has no value will become more valuable.
4. Business feasibility analysis using payback period, net present value, and Profitability index showed positive results. The payback period shows a result of 0.9 years, so it takes 11 months to return the investment that has been spent. The net present value is worth 300,000, and this number is> 0, which shows that this Business is positive and feasible

to run. The profitability index shows 1.1%. The value is also greater than 1, so running is feasible.

5. All the results of the study conducted can be taken into consideration by the manager to continue the waste management proposal.

6.2 Suggestion

Suggestions to the Tempel market manager after conducting an organic waste management simulation study are:

1. For the Tempel Market manager

   The Tempel Market manager is expected to improve waste management in the Tempel Market. In the absence of good management, there will be a buildup of waste in the Tempel market temporary waste disposal. The accumulation of waste will negatively impact if there is no further waste management. The results of this study are expected to be an additional consideration for starting waste management in the Tempel market.

2. For further research

   Future research is expected to make this research report a reference for producing better results. Other research is also expected to develop with other research methods to compare the results of this study. Other research methods are used to compare the results of this study.

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APPENDIX

Appendix 1. Table Sampling Waste in Tempel Market

No	Date	Sample (kg)			Average	Sample High (m)	Volume Sample (m2)	waste in temporary waste disposal			
		S1	S2	S3				length (m)	width (m)	height (m)	volume (m2)
1	4-Feb-24	2.76	2.715	2.62	2.698	0.3	0.0212	3.5	3	0.6	6.3
2	5-Feb-24	2.115	2.51	2.85	2.392	0.296	0.0209	3.6	2.9	0.6	6.264
3	6-Feb-24	2.9	3	2.6	2.833	0.293	0.0207	3.6	2.7	0.7	6.804
4	7-Feb-24	2.9	2.575	2.7	2.725	0.29	0.0205	3.7	2.5	0.6	5.55
5	8-Feb-24	2.65	2.645	3	2.765	0.303	0.0214	3.1	2.8	0.7	6.076
6	9-Feb-24	2.6	2.6	2.85	2.683	0.303	0.0214	3.1	2.8	0.7	6.076
7	10-Feb-24	2.375	2.35	2.5	2.408	0.303	0.0214	3.9	3	0.5	5.85
8	11-Feb-24	2.495	3	2.665	2.72	0.296	0.0209	3	2.8	0.7	5.88

Appendix 2. Waste generation in Tempel Market

No	Date	Sample weight	Sample Volume	Waste Volume in TPS	weight waste
1	4-Feb-24	2.698	0.0212	6.3	801.76
2	5-Feb-24	2.392	0.0209	6.264	716.91
3	6-Feb-24	2.833	0.0207	6.804	931.19
4	7-Feb-24	2.725	0.0205	5.55	737.74
5	8-Feb-24	2.765	0.0214	6.076	785.05
6	9-Feb-24	2.683	0.0214	6.076	761.77
7	10-Feb-24	2.408	0.0214	5.85	658.26
8	11-Feb-24	2.72	0.0209	5.88	765.24

Appendix 3. Sythetic Data from Waste Generation

month	1	2	3	4	5	6	7	8	9	10	11	12
	759243	679027	817050	671174	786138	702845	860614	815068	903561	674057	876333	833541
	754387	846315	714576	703386	679283	689464	712944	792027	802717	889485	799415	745222
	679879	693062	876186	784619	919395	779198	798301	828906	673760	699041	759770	674708
	792301	775654	915437	750665	679060	819206	909501	752085	908204	716749	893796	842381
	839372	732747	892875	873948	827981	905992	814999	787380	692374	661562	666905	669199
	756664	746158	788133	692214	748228	909190	908684	730900	736426	878634	907001	907366
	684338	677420	859888	775591	753260	688279	742824	816439	810933	908636	811054	857188
	873882	837311	671775	811778	896307	836081	836263	898626	716703	813895	832109	858231
	915592	882932	767381	928952	703566	722277	890380	862512	921982	854468	691650	837905
	922004	814573	772383	897289	690360	822542	852314	857810	755299	748161	798188	676651
	828892	876509	869092	846762	704068	767684	868020	800688	791706	820096	662497	737281
	814547	816876	666711	750972	872216	789882	659599	702147	710711	726927	754011	750268
	882719	746189	765440	733565	918456	723702	737376	899033	827038	921389	908753	913303
	812384	844338	906869	760075	682747	744428	701804	721925	871962	747636	706819	661083
	883482	684779	929314	732185	781357	665456	661831	691249	779620	887547	767739	675158
	665807	666214	849312	927869	868993	895965	785213	738126	826845	788178	791752	870651
	735719	911500	800017	738978	794544	814268	745826	673499	789679	898290	682998	850669
	835174	780072	905326	871083	673400	803339	797783	809152	890627	865209	728617	730003
	732120	864412	806502	817393	752512	911449	753504	859678	815671	906673	886297	666710
	894128	673989	754684	796833	703727	878248	682510	726573	910209	879321	927753	760157
	739699	765030	862161	757050	808623	930739	697591	847565	838157	663809	838666	878738
	908841	702429	717459	901774	899690	689308	881230	755707	880181	727972	680188	847535
	832826	719286	801054	683137	886165	716405	841767	844954	708292	724529	849297	688691
	731363	701911	845487	695222	815262	813505	863492	753538	820292	911355	812795	789265
	886185	720020	727745	929514	846977	855035	916492	691015	829298	667104	659091	799607
	660146	837175	863946	920614	672991	748728	860250	862596	883726	857381	800008	871171
	702178	922696	896791	666959	702019	751406	685290	863363	909629	849445	848439	784997
	892844	816213	841170	885062	917463	867366	659798	917588	702713	817979	899609	730880
	861675	722015	896926	788721	840661	711588	762795	785217	763411	774065	921101	706234
	674018	855153	900451	735257	776401	809964	750934	856786	753342	690248	694345	855244
total	23952409	23312005	24682141	23828641	23601850	23763539	23639929	23942152	24225068	23969841	23856996	23470037
kg	23952.41	23312.01	24682.14	23828.64	23601.85	23763.54	23639.93	23942.15	24225.07	23969.84	23857	23470.04

month	13	14	15	16	17	18	19	20	21	22	23	24
	795364	916595	767902	700903	920263	672792	719308	831429	867201	679515	852817	926547
	744591	768482	840921	896211	668779	897416	763047	737519	776590	830709	873657	802490
	840040	693686	772297	776564	800421	900250	800423	810070	752554	862477	700014	900226
	696800	733646	877556	745784	683140	699412	902324	881050	883190	679811	889953	806600
	785783	802570	682584	781334	903415	826769	734446	722399	696654	773564	759629	736434
	762346	864189	907471	721762	717828	808004	840682	838228	734015	922494	924500	880085
	879518	744152	851850	666699	769048	720365	717906	658368	867193	816772	842660	909347
	743731	907444	718910	880537	702462	760370	848633	865926	902392	723066	699403	827940
	802963	912094	788372	810418	664737	689371	688297	836171	836309	722353	863670	899372
	877610	807890	690677	900184	676017	777940	758709	772039	756485	687537	796845	688858
	919367	768685	856855	702830	911818	805643	857129	810247	663158	887954	701521	872088
	873801	688831	873946	896472	910512	884498	874515	773196	698414	906194	915760	708969
	905873	921059	724347	757076	720429	676693	799382	770793	868637	820709	818586	680241
	695024	849493	685331	676689	802039	852211	697344	765042	832026	659632	905502	697820
	731527	713935	694751	843835	752965	824851	907125	758731	671235	685823	741496	683099
	916872	754831	696911	708443	767800	863725	891305	863549	890776	800247	836823	752200
	685203	722674	750606	788017	709198	745132	762398	860857	675143	663556	787024	877126
	792180	793491	875076	728424	824563	927037	719215	818530	710676	726998	702226	887680
	825344	744018	876138	925996	842750	902148	720626	886940	754609	866388	666508	832377
	716900	857730	729173	714038	778698	818575	757568	673610	724035	930758	659587	915860
	709669	676206	838487	915232	908264	795455	690960	791289	765522	856232	736660	769402
	698741	781573	903307	671918	744505	904772	849789	886154	688964	928718	711897	878088
	892395	836485	924986	906573	776225	803400	911500	807483	835753	913225	893933	864570
	930969	659081	685464	849115	906179	755000	733181	842110	689884	909681	886516	684369
	659997	778442	880450	834504	837343	831169	872757	769307	671098	864742	817315	897049
	773219	851490	877350	752449	820177	840082	789201	745876	920383	753393	783690	787937
	801012	842348	720813	844591	738161	782379	857079	796428	707065	703916	806065	700506
	685930	858326	887170	686627	876422	755273	721673	782220	659079	929523	926992	836632
	658617	699093	838233	684907	748748	661872	677376	850661	722116	777942	840438	678516
	681712	814413	826485	900807	784220	761620	670468	825252	862442	893115	893275	711399
total	23483098	23762952	24044419	23668939	23667126	23944224	23534366	24031474	23083598	24177044	24234962	24093827
kg	23483.1	23762.95	24044.42	23668.94	23667.13	23944.22	23534.37	24031.47	23083.6	24177.04	24234.96	24093.83

month	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
	897891	919304	875625	727349	699340	904001	669006	806830	925360	780809	872280	780113
	772160	685289	770565	772833	896321	748315	777719	841140	732561	919816	797985	678134
	887530	839340	804447	702314	919284	793851	822773	719340	749800	823998	754896	784662
	823576	691893	724064	675554	689035	867971	677831	840150	690630	753197	815795	825011
	665387	885571	857798	851556	694244	829279	860061	849887	878013	811769	743857	918495
	820020	661176	662630	857523	687304	711463	743610	929208	686952	733251	784011	737362
	886694	859192	866534	814849	721322	787657	712037	683355	885474	879111	871493	853412
	705717	817094	761815	897715	727256	869696	683913	853790	821705	689370	760952	802058
	753434	918533	761671	862527	808083	694639	921124	756200	708933	704030	921891	753550
	723849	720798	863967	672632	915601	860423	701752	740589	687699	713155	854906	766249
	783598	865423	699792	872480	703692	864946	676303	803544	776460	666956	719034	672200
	929668	867626	706396	922964	751166	755017	710948	801719	694315	886763	847992	723437
	829301	733619	662389	676635	658415	799197	923248	925911	667138	725561	762990	689093
	817908	745166	833559	691816	706033	749556	687485	919009	908796	870366	920133	715970
	684116	856374	833954	871028	749371	679422	804429	801687	908245	833655	667169	712869
	777344	854519	679039	863187	900571	691317	870087	888101	865117	915421	905162	885943
	846391	752510	863687	714865	874100	852240	851557	772787	903287	893730	897919	778362
	865343	855330	758279	835653	728722	923475	916142	683500	704542	897030	723973	870265
	843570	802547	874047	927789	822598	679440	706511	739868	719771	829254	730958	926217
	904170	887955	716056	855104	903982	921645	821658	756645	821470	772410	711329	767352
	926944	697407	712789	662916	699052	846727	808771	815133	867696	854945	843103	817654
	914082	767834	667442	708185	704758	915910	824912	690717	665050	923859	666499	867641
	740356	695776	922939	745190	910157	843146	848698	764743	677942	716969	740219	823532
	807476	815493	697576	686530	768096	750175	811074	663185	905840	733278	877486	878660
	726724	759327	796859	903395	684415	677267	663221	711370	706003	803039	860365	923177
	875630	817492	862319	778491	846215	768794	813453	719842	832269	798649	728007	795767
	732836	693312	826152	809573	785118	881710	814792	761597	725056	843057	903818	821842
	717619	753647	662846	712003	719958	863561	663959	930853	752389	799033	785788	768386
	753163	687589	775926	731433	809486	871631	930127	750113	658406	809160	812226	821064
	825963	736993	795105	690871	735083	750146	816425	681391	671073	781747	815205	846569
total	24238460	23644129	23296267	23494960	23218778	24152617	23533626	23602204	23197992	24163388	24097441	24005046
kg	24238.46	23644.13	23296.27	23494.96	23218.78	24152.62	23533.63	23602.2	23197.99	24163.39	24097.44	24005.05

Appendix 4. Information Every Variable Powersim Application

No	**Variables**	**Measurements**	Definition
1	The population of Lumbungrejo	Person	Initial population
2	Number of traders	person/Mo	570
3	Waste generation from traders	kg/Mo	Number of trader * traders rubbish per day / 1 <<person/mo>>
4	Waste generation per person	kg/Mo	People going to market *
5	Garbage at the market landfill	kg	Residents who go to the market every day* Trash per person / 1 <<person/mo>>
6	Landfill waste generation	kg	
7	Garbage sent	kg/Mo	RANDOM (12000,20000) *1<<kg/mo>>
8	Piyungan landfill capacity	kg	Garbage sent *1 kg
9	Trader's rubbish per day	kg/Mo	RANDOM (1,1.32) *30 <<kg/mo>>
10	Trash per person	kg/Mo	RANDOM (0.3,0.5) *30<<kg/mo>>
11	Residents who go to the market every day	person/Mo	The number of residents potentially going to the market* People going to the market
12	People going to the market	%	58%
13	The average potential population goes to the market	%	53%
14	The number of residents potentially going to the market	person/Mo	Number of family card * The average potential population goes to the market
15	Number of family card	person/Mo	the population of lumbungrejo / number of families in one family*1<<person/mo>>
16	Number of families in one family	person	3 persons
17	Population death	person/Mo	The population of Lumbungrejo * death rate
18	Death rate	%/Mo	RANDOM (0.1,0.25) *1<<%/mo>>
19	Population birth	person/Mo	Birth rate * the population of Lumbungrejo
20	Birth rate	%/Mo	RANDOM (0.43,0.61) *1<<%/mo>>
21	Weight of organic waste	kg/Mo	0.7778 * garbage in the market landfill
22	Weight of inorganic waste	kg/Mo	0.2222* garbage in the market landfill
23	Total organic waste	kg	Weight of organic waste *1*1 <<kg>>
24	Total inorganic waste	kg	Weight of inorganic waste *1*1 <<kg>>
25	Total unmanaged waste	kg	Unmanage Organic waste + unmanage inorganic waste *1<<kg>>
26	Waste managed by BSF larvae	kg/Mo	Larva BSF population *BSF larvae feeding
27	BSF larvae feeding	kg/Mo	0.0015
28	Total waste reduction by BSF larvae	kg	Waste managed by BSF larvae *1<<kg>>
29	Compost fertilizer from BSF larvae	kg	Organic residue * 1<<kg>>
30	Organic waste residue	kg	Waste digested by BSF larvae – Total waste reduction by BSF larvae
31	Waste digested by BSF larvae	kg	Percentage of BSF larvae feed consumption * total waste reduction by BSF larvae
32	Percentage of BSF larvae feed consumption	%	0.86

33	Garbage that eaten by BSF larvae	kg	Waste digested by BSF larvae *1 <<kg>>
34	Maggot Eggs hatched in one biopon	grams	5
35	Number of larvae per one gram of eggs	larva/Mo	RANDOM (8000, 8300) *1<<ekor/mo>>
36	Number of BSF larvae in one biopond	larva/Mo	Number of larvae per one gram of eggs * Maggot Eggs hatched in one biopon
37	Number of BSF larvae in one rack	larva/Mo	Number of BSF larvae in one biopond * Number of bioponds in one rack
38	Number of bioponds in one rack	10 units	10
39	Maggots are born in one life cycle	larva/Mo	Number of BSF larvae in one rack * Total shelves available
40	Total shelves available	9 units	9
41	BSF larval population	larva/Mo	Maggots are born in one life cycle
42	Harvest BSF larvae	larva	Larva BSF read to harvest * 1 <<kg>>
43	Weight of earthworms per head	kg/head	0.00075*1<<kg/ekor>>
44	Weight of earthworms in one biopond	kg	2 * 1 <<kg>>
45	Number of earthworms in one biopond	Worm	Weight of earthworms per head * Weight of earthworms in one biopond
46	number of earthworms in one rack	worm	Number of earthworms in one biopond * Number of bioponds in one rack
47	number of earthworms bioponds in one rack	2 units	2
48	Number of worms in one management cycle	worm	number of earthworms in one rack * total rack of earthworms in one harvest
49	total rack of earthworms in one harvest	9 units	9
50	Earthworm population	Worm /Mo	Number of worms in one management cycle
51	Earthworms ready to harvest	worm	1* Earthworm population
52	Harvest earthworms	worm	Earthworms ready to harvest * 1 <<kg>>
53	Average weight of earthworms after rearing	kg	0.000375*1<<kg>>
54	Earthworms that are ready to harvest	kg*worm	Harvest earthworms * Average weight of earthworms after rearing
55	Harvest earthworms	kg*worm	Earthworms that are ready to harvest
56	Waste digested by earthworms	kg	Garbage that eaten by earthworms * Waste managed by earthworms
57	Earthworm compost	kg	Residue organic waste *1 <<kg>>
58	Waste managed by earthworms	kg/Mo	Earthworm feeding * population of earthworm / 1 <<worm / mo>>
59	Garbage that eaten by earthworms	kg	Waste digested by earthworms * 1 <<kg>>