LONG-TERM FOOD WASTE MANAGEMENT IN PHNOM PENH UTILIZING THE SYSTEM DYNAMICS MODELLING APPROACH: A CASE STUDY OF CHAMKAMON AND DAUN PENH DISTRICTS, PHNOM PENH, CAMBODIA

BY

MS. SIREIRATANA THAY

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE (ENGINEERING AND TECHNOLOGY)

SIRINDHORN INTERNATIONAL INSTITUTE OF TECHNOLOGY

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Thesis Title	LONG-TERM FOOD WASTE MANAGEMENT IN PHNOM PENH UTILIZING A SYSTEM DYNAMIC MODELLING APPROACH: A CASE STUDY OF CHAMKAMON AND DAUN PENH DISTRICTS, PHNOM PENH, CAMBODIA
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ABSTRACT

Phnom Penh, the capital city of Cambodia, has high population growth that leads to high amount of food waste. This creates a number of environmental impacts, such as global warming, methane emission, and ground water contamination. To properly manage food waste, it is necessary to identify key factors affecting food waste management. Moreover, the interactions among key food waste factors are required to effectively plan for the long-term food waste management. This study develops the dynamics model of food waste management, utilizing the system dynamics modelling approach, to investigate trend of food waste in Phnom Penh, and plan for food waste management in the long-term. The developed dynamics model considers two major sources of waste, namely household and retailer wastes with a total of 12 key factors affecting food waste management. The simulation results reveal that majority of food wastes come from households, and that they are mainly from inappropriate preparation processes, inappropriate packing sizes, and unfinished promotion packs. Policy analyses, performed through the developed dynamics model, suggest to reduce waste

during preparation processes, use packing sizes that match with customer requirement, and consider promotions that are suitable for short-life products, including vegetables. Those strategies assist for long-term food waste management, and mitigate landfill and environmental problems in Phnom Penh. Cooperation among households, retailers, local authority, and government are crucial to sustain the implementation plan in the long-term.

The developed dynamics model of food waste management raises concerns of food waste and landfill problems, and suggest a number of plans for households, retailers, local authority, and government to be used to manage food waste in the long-term.

Keywords: Bio-digester, food waste management, household waste, landfill, Phnom Penh, retailer waste, system dynamics modelling

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Ms. Sireiratana Thay

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LIST OF SYMBOLS/ABBREVIATIONS

Symbols/Abbreviations	Terms
FIFO	First in First out
MSW	Municipal solid waste
SD	System dynamics
SIIT	Sirindhorn International Institute of Technology
SWM	Solid waste management
TU	Thammasat University

CHAPTER 1
INTRODUCTION

1.1 General overview

This chapter introduces the background information of the research study. Population growth in Cambodia and Phnom Penh, food waste problems, and landfill issues are pinpointed in this chapter. Problem statement, research aim, and research objectives are then explained at the end of this chapter.

1.2 Cambodia and Phnom Penh population

Cambodian population was 15,848,500 persons in 2017 (NIS, 2013). The annual growth rate of population is around 1.56% per year (NIS, 2013). The country consists of 10 cities, with Phnom Penh as a capital city. Phnom Penh has 12 districts, 110 communes, and 964 villages (Gazetteer Database Online, 2018). It has around 11% of total country population (World Population Review, 2019). Currently, the city experiences high growth rate, with an average increasing rate of 12.4% per year (NIS, 2013). Apart from that, the city has high number of immigrants, with an increasing rate of around 3.2% per year (NIS, 2019). With high number of population, the municipal solid waste (MSW) is expected to increase.

1.3 Municipal solid waste

Municipal solid waste (MSW) is the waste from domestic, commercial, and institutional (Sour et al., 2014). It is a major problem around the world, and its management is a challenge issue as it is impacted by various factors, such as political, legal, education, and financial factors (Hoklis and Sharp, 2014). Manaf et al. (2009), for example, stated that solid waste management is a serious environmental-related issue, as an urbanization continues to increase. Seng et al. (2011), on the other hand, stated that Phnom Penh currently faces a serious environmental issue on how effectively manage the MSW.

In Phnom Penh, the average MSW per day in 2013 was around 1,550 tons, or around 0.91 kg of waste generated per person per day (Hul et al., 2015). According to Vanda and Heilman (2015), MSW is separated into food waste, paper/cardboard,

wood/glass, plastic, metal, textile, glass, and others. More than half, or around 63.3%, of MSW comes from food waste (Seng et al., 2011). With more population in Phnom Penh, food waste problems seem severed.

1.4 Food Waste

According to FAO (2013), food waste is waste thrown away, whether or not it is expired. Main reason that food is often kept until it is spoiled is because of an oversupply on the markets, individual consumption, and eating habit. According to Cox and Downing (2007), there are many types of food waste, such as inedible food, fruits, vegetables, raw meat, processed meat, ready meals, cheese and yogurt, bread and cakes, food left on plate after meal, food prepared but not served, food saved from previous meals, products opened but not finished, and products purchased but not opened. Quested and Johnson (2009), however, divided food waste into eight types, including 1) fresh fruits, 2) fresh vegetables, 3) meat and fish, 4) drink, 5) bakery, 6) dairy and eggs, 7) meals, and 8) others.

Russell et al., (2017) mentioned that food waste is a huge worldwide issue, and around 33% of edible food is wasted every year. Food waste causes high amount of methane emission, and creates a number of environmental-related problems (Hoklis and Sharp, 2014). Food waste is normally dumped into landfills. Stung Meanchey landfill, the old landfill in Phnom Penh, was closed since 2009 as its capacity was reached earlier than planned. A new site, Dangkao landfill, which is 15 km from Phnom Penh city, was then opened for use (see Figure 1.1). Currently, the landfill utilizes around 70% of the space with food waste. Without proper waste management, the landfill will be full in short period of time, causing a number of environmental-related problems, such as groundwater contamination, methane emission, greenhouse effect, and climate change. Methane emission, especially, was rapidly increased by 5.0 Gg per ton in 2013. If more waste is dumped into Dangkao landfill, the methane emission will reach 12 Gg per ton in 2030 (Hul, 2017).

Figure 1.1 Dangkao landfill

1.5 Problem statement

Food waste causing major problems in Phnom Penh, such as landfill shortage and greenhouse effect, and loss of economy. With more food waste purchases, it is expected that the country faces various social-, environmental-, and economic-related problems. Long-term plan is, therefore, needed to sustainably manage food waste. All parties, including households, retailers, local communities, local authorities, and government must cooperate to effectively plan and implement food waste management program to reduce the amount of waste, and enhance environmental standard of the country in the long-term.

1.6 Aim and Objectives

This study develops a system dynamic (SD) model of food waste management to study the trend of food waste in Phnom Penh in the long-term. The developed dynamics model consists of two main parties, namely households and retailers, who are major sources of waste. It is expected that the study results pinpoint key factors affecting food waste management, and provide strategies, with cooperation from households and retailers, together with local authorities and government, to effectively manage food waste, and reduce environmental impacts in Phnom Penh in the long-term.

To achieve the research aim, a number of research objectives are listed.

- Extracting key factors affecting food waste management in Phnom Penh, Cambodia.
- Collecting secondary and primary data to be used for the dynamics model development.
- Developing the dynamics model of food waste management utilizing the SD modelling approach.
- Simulating the developed dynamics model to examine the trend of food waste in Phnom Penh in the long term.
- Suggesting a number of strategies, through the policy analysis, to be used to reduce food waste in the long-term.

1.7 Thesis Organization

This thesis consists of seven chapters. The main contents of each chapter are described below.

- Chapter 1 introduces background of the study, population in Cambodia and Phnom Penh, waste situation in Phnom Penh, research problem, research aim, and objectives.
- Chapter 2 reviews number of literatures related to food waste management, and extract key factors affecting food waste management.
- Chapter 3 outlines the research methodology and research flow. Brief details of each chapter, key analyses used in this study, and expected outcomes are explained in this chapter.
- Chapter 4 presents data collection, both secondary and primary data, to be used to develop the dynamics model of food waste management.
- Chapter 5 develops the dynamics model of food waste management utilizing the SD modelling approach. Simulation results are also explained in this chapter.
- Chapter 6 preforms a number of policy analyses to reduce the amount of food waste in the long-term.
- Chapter 7 summarizes main findings, limitations of the study, and recommendations for future research.

CHAPTER 2
LITERATURE REVIEW

2.1 General overview

This chapter reviews literature related to food waste management. Key factors influencing food waste management are extracted, based on households and retailers perspectives, and are explained in details.

2.2 Trend of food waste in Phnom Penh

Recently, there has been increasing international interest on the amount of waste and its negative consequences, as the average annual MSW has gone up rapidly from 0.136 million tons in 1995 to 0.361 million tons in 2008 (Seng et al., 2011). With more MSW generation, the amount of food waste increases. In Phnom Penh, the rate of gross generation per capita was more than 0.74 kg/day in 2003, and it is expected that, by 2030, it would be increased to 1.24 kg/day (Hul et al., 2015). This represents the increase in daily waste generation of about 12.1%, leading to the waste generation of around 2200 tons/day in 2020 (Spoann et al., 2018).

In Cambodia, popular dishes that are usually cooked always contain vegetables, which are cheap and always on promotions. This, in turn, causes high amount of food waste. Vegetables may be cut and peeled off the edible parts, leading to more trashes. Cambodian people usually cook stir-fried and soup dishes with various kinds of vegetables. According to Nomadicboys. (2015), Lok Lak is a common Cambodian beef stir-fried served with cucumbers, tomatoes, and lettuces. Cha Tra Kuen is another popular stir-fired dish served with morning glory (IKnow, 2018). Trey Cha Cho Em is, on the other hand, popular fish dish, deep fried with tomatoes, carrots, and lettuces (Bongpet, 2015). Somlor Machou Kroeung is a delicious soup, with morning glory, and capsicums as main ingredients (Yuen, 2015) (see Figure 2.1).

Main vegetables used in popular Cambodian dishes are summarized in Table 2.1.

Lok Lak

Cha Tra Kuen

Trey Cha Cho Em

Somlor Machou Kroeung

Figure 2.1 Popular dishes in Cambodia

Table 2.1 Main vegetables ingredients of popular Cambodian dishes.

Menu	Average portion (g/person)					
	Carrot	Capsicums	Cucumber	Lettuce	Morning Glory	Tomato
Lok Lak	-	-	154	30	-	90
Cha Tra Kuen	-	-	-	-	150	-
Trey Cha Cho Em	30	43	-	-	-	45
Somlor Machou Kroeung	-	85	-	-	62.5	-

Note: References include IKnow (2018), Bongpet (2015), Nomadicboys (2015), Yuen (2015)

2.3 Factors affecting food waste management

In this study, sources of food waste come from two major groups, which are households and retailers. Vegetable is considered as a major source of food waste in this study, as it is the main ingredient in many dishes, has cheap prices, and has short-life span (Mena et al., 2011). Household waste may come from, for example, unfinished food, waste during food preparation processes, and waste from mismatched packing (Žitnik and Vidic, 2016). Retailer waste, on the other hand, may be achieved when order quantity does not match with household demand and shelf-life of vegetables.

Factors affecting food waste management based on household and retailer are listed and explained in the following sections.

2.3.1 Factors affecting food waste management: household perspectives

According to JICA (2005), household waste consists mainly of food, rubber, metal, and plastic, representing 63.3 %, 15.5%, 6.8%, and 6.4%, respectively. Many research studies identify different causes of food waste generation in households. Pai et al. (2014), for example, mentioned that high population growth can severely increase food waste. Žitnik and Vidic (2016), on the other hand, stated that up to 11% of food ingredients may be wasted during preparation processes. Schanes et al. (2018) suggested households to shop more often with less amount to reduce leftover and waste.

In this study, a total of seven key factors affecting food waste are extracted from a number of waste-related literature. They include 1) population, 2) family size, 3) family member, 4) shopping frequency, 5) price index, 6) food preparation, and 7) bio-digester. Details are as the followings.

2.3.1.1 Population

Pai et al. (2014) mentioned that high growth rate leads to high amount of food waste. There are 1,447,340 persons in Phnom Penh, or around 284,721 households in 2015 (CDB, 2015). The number of population is expected to increase by 3.15% within the next five years (World Population Review, 2019). More population lead to more wastes, including food waste, as the average waste generation per person is around 0.91 kg/day (IGES, 2011).

In this study, the population in Chamkamon and Daun Penh districts, two major districts in Phnom Penh, are selected as case studies in this research. The population of these two districts are 308554 persons in 2018, or around 10% of total population in Phnom Penh.

2.3.1.2 Family size

According to NIS (2013), there are two common sizes of family in Cambodia, including small- and large-sized families. Small-sized families in Cambodia tend to be increased by 2.7% per year due to changes of life styles (NIS, 2013). More of nuclear and no-kid families tend to be increased. Demont and Heuveline (2008), however, mentioned that minimum percentage of large-sized families is around 12% of total households.

2.3.1.3 Family member

According to NIS (2013), small-sized families have up to three members in a family, while large-sized families have an average of six members in a family. Small-sized family with less family members may require less portion of food per meal. Large-sized families, in contrast, may need bigger portion with different dishes per meal.

2.3.1.4 Shopping frequency

Schanes et al. (2018) mentioned that wastes can be reduced when households shop more often with less amount per shopping. Daily shopping could be possible with households who have time, and often cook their own meals. Households who live far from the supermarkets may, though, not be able to shop every day. Instead, they may consider shopping once or twice a week, with more food amount per shopping. This may, in turn, lead to higher amount of food waste if households cannot finish the food on time.

In this study, shopping frequency is separated into every day, twice a week, and once a week. Demand on food also depends on dishes cooked per meal, number of meals cooked per day, and sizes of family.

2.3.1.5 Price index

Morone et al. (2016) mentioned that increases in product prices reduce consumption rate. In this study, average price of vegetables used in popular dishes is used in the dynamics, model development, with the minimum and maximum prices of 1 USD and 1.65 USD per kg, respectively (DPSTI, 2019).

2.3.1.6 Food preparation

Food waste may occur during food preparation processes. Some vegetables must be peeled their rim off, or cut the skin before they are cooked. Some of them may be burnt, over cooked, or under cooked, and must be thrown away. Žitnik and Vidic (2016), mentioned that 2-11% of total ingredients are wasted during preparation processes.

2.3.1.7 Bio-digester

With a growing concern on environment and global warming, bio-digester is encouraged to be used in many countries (Ministry of Agriculture, 2016). Bio-digesters are natural systems that use food waste to produce biogas and natural fertilizer utilizing anaerobic digestion (Martí-Herrero, 2008). Shenzhen Sunrise Econergy (2013), added that, when food wastes are kept in an anaerobic digester, the bacteria will break down the organic wastes, and transfer the organic matters into methane, hydrogen sulfide, carbon dioxide, and nitrogen. Methane can then be used as cooking fuel or run a gas generator to generate electricity (Martí-Herrero, 2008; Shenzhen Sunrise Econergy, 2013).

The cost of bio-digester ranges from a cheap price of 150 USD/unit to an expensive one of 1,000 USD/unit. The cheap-price bio-digester can convert around 188 kg of waste into around 1.25 kWh of electricity per day (Martí-Herrero, 2008). The expensive one, in contrast, has around seven times of its capacity compared with the cheap one.

In this study, the investment cost of a bio-digester is 150 USD with a 2-year life-span. This is considered as an affordable price for Cambodian households and local community. Electricity generated by a bio-digester is around 1.25 kWh/day, on average

(Martí-Herrero, 2008). This could save around 57% of electricity cost (Romo-Rábago, 2014).

2.3.2 Factors affecting food waste management: retailer perspectives

According to Yim et al. (2014), food waste is a major type of wastes generated by commercial and retail sectors in Phnom Penh. In this study, five key factors affecting food waste management based on retailer perspectives are listed. They include 1) packing size, 2) promotion, 3) shelf-life, 4) order quantity, and 5) stock rotation. Details are as the followings.

2.3.2.1 Packing size

Aschemann-Witzel et al. (2015) mentioned that around 20-25% of food waste are wasted due to mismatched packing sizes. There are a number of suggestions to reduce the package sizes to maintain food quality and reduce food wastage. Sharon (2017) added that to reduce food waste, good management on packing sizes should be considered.

In this study, two common packing sizes are used in the dynamics model development. They are achieved from interviews and observations from a supermarket in Phnom Penh. Details are explained in Chapter 4.

2.3.2.2 Promotion

Promotion is one of the useful methods to reduce food wastage, and increase supply chain management. However, quality of food might be an issue of concern, as most of on sales products are almost at the end of their shelf-life. Blattberg and Neslin (1989) mentioned that households tend to buy more supplies when the prices dropped. This, however, may lead to products being expired, and must be thrown away, resulting in more wastes dumped into landfills. According to Waste Management World (2015), over supplied productions are usually sold at a discount price, or are thrown away if their quality does not meet with the specifications. Promotions, such as “buy 4 get 1 free” and “buy 1 get 1 free” may result in higher food wastes, as households may not be able to consume the products before their expiry dates.

2.3.2.3 Shelf-life

According to Mena et al. (2011), shelf life is a key factor affecting food waste, especially for fruits and vegetables, as they are affected by short time span of usability, temperature and sensitivity, and micro-bacteria issues. Even the shelf life is being controlled properly, fruits and vegetables in tropical countries might be damaged quicker than those in western countries. Every year, tons of fruits and vegetables are thrown away, as they get spoiled. This results in high amount of food waste.

In this study, an average shelf-life of vegetables used in the dynamics model development is one week. This comes from the shelf-life of seven, seven, five, seven, and seven days for cucumber, tomato, lettuce, morning glory, and carrot used in popular Cambodian cooking, respectively (Eat By Date, 2015).

2.3.2.4 Order quantity

Order quantity refers to the ideal order quantity a company should purchase to minimize inventory (Investopedia, 2019). Proper order quantity helps retailers to reduce waste. Issues, such as short-life products, promotion schemes, and stock rotation method should be considered when determining the order quantity to achieve the best amount with the minimum waste amount (Alsabrook, 2016).

2.3.2.5 Stock rotation

There are various types of stock rotation used in the management of short-life products, such as managing inventory and first-in first-out (FIFO) method (Alsabrook, 2016). The FIFO method is commonly used for vegetable management to ensure that the oldest goods are be sold before they pass their sell-by dates (Arafa, 2019).

2.4 Summary of factors affecting food waste management

In summary, seven and five key factors affecting food waste management based on households and retailers, respectively, are extracted from a number of waste-related literature. They are later used for data collection to gather data to be used for the development of the dynamics model of food waste management.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 General overview

This chapter describes research flow of this study. The introduction of system dynamics (SD) modelling approach, the key analysis approach, is also presented in this chapter.

3.2 Research flow of the study

Research flow of this study is as shown in Figure 3.1. Literature review related to food waste management is reviewed to extract key factors affecting food waste management in both household and retailer perspectives. They are from various sources, such as journal papers, statistics reports, company reports, websites, and text books. A total of 12 key factors affecting food waste management are extracted in this study, and used for data collection. Secondary data are achieved from various sources, such as international journals, company's reports, and government related websites. World Population Review (2019), for example, mentioned that initial population in Chamkamon and Duan Penh districts in 2018 was 308554 persons. Pai et al. (2014), on the other hand, mentioned that more population leads to more wastes. Romo-Rábago (2014) stated that bio-digesters can be used to reduce the amount of food waste, as waste is converted to energy. Žitnik and Vidic (2016) mentioned that food waste may occur during food preparation processes, and that provision of cooking knowledge may help reduce the amount of food waste. Schanes et al. (2018) stated that food waste may be reduced when households shop more often with less amount.

The interview and observation are, on the other hand, used for primary data collection. The interview and observation were conducted for two-month period, from June-July, 2018. Key interviewees include both householders and retailers. Householders living in Chamkamon and Daun Penh districts are selected based on assumption that they regularly shop at the supermarkets. They are asked questions related to the 12 key factors affecting food waste. Examples of questions are their popular dishes, frequency of their shopping, members in their family, and number of

meals cooked per day. A representative from the well-known retailer in Chamkamon and Daun Penh districts is also interviewed to gain data for the dynamics model development. Examples of data include promotion schemes used in the supermarkets, available packing sizes, stock rotation method, and order quantity.

Secondary and primary data collected are used to develop equations of the dynamics model of food waste management. In this study, the SD modelling approach is used to develop the dynamics model of food waste management in Phnom Penh, Cambodia. The model consists of three main sub-models, including household, retailer, and bio-digester and landfill sub-models. The developed dynamics model is then simulated, and the simulation results show trend of food waste in Phnom Penh in the long-term. A number of strategies are finally performed with the developed dynamics model to recommend the strategies to reduce food waste in the long-term. Local community, local authority, and government may use the recommendation strategies to plan for food waste management in the long-term.

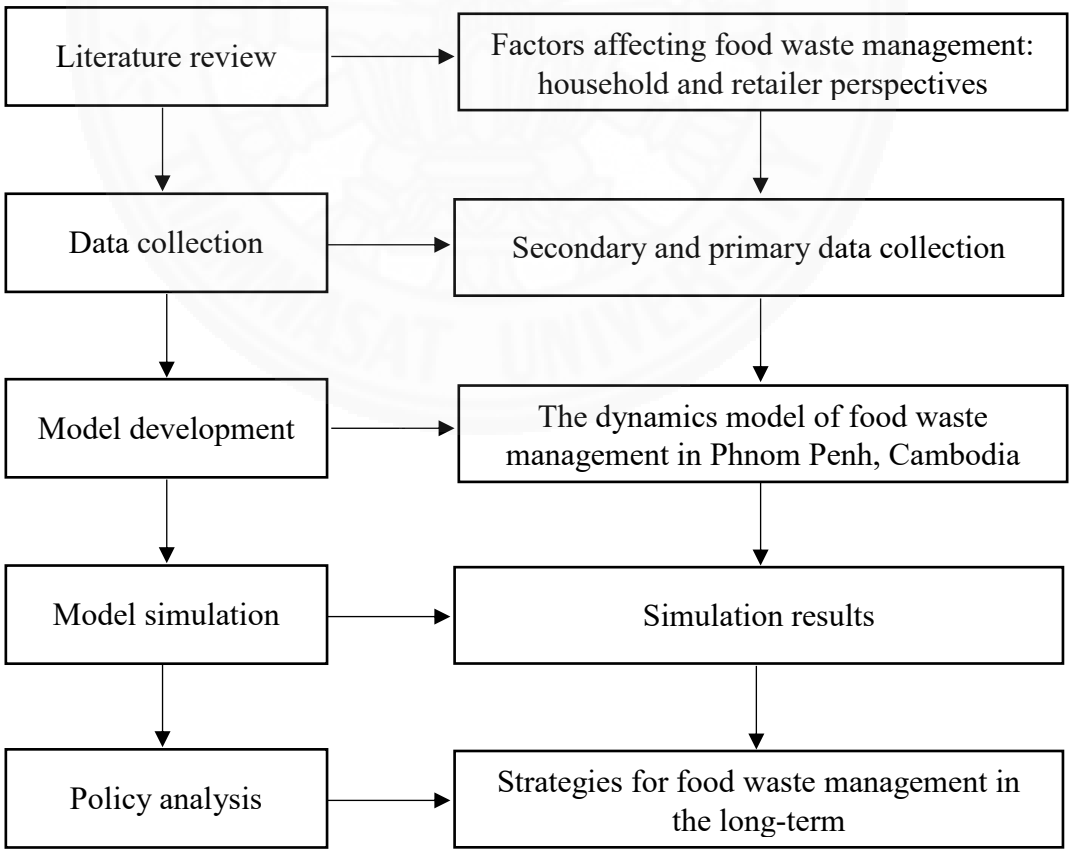

Figure 3.1 Research flow of this study.

3.3 Introduction to system dynamics modelling approach

The SD modelling approach is used to develop the dynamics model of food waste management in this study. It is a model equation developed from description, and simulated to perceive a dynamic situation, assessment of policies, and training and decision of a superior strategy (Forrester, 2006). It has been applied in many areas of studies, such as hospital management, landfill management, waste management, and real estate management. Chaerul, et al. (2008), for example, utilized the SD approach to examine interacting factors in a hospital waste management system in Jakarta, Indonesia, and concluded that proper waste generation is needed to reduce the public health risks. Kollikkathara et al. (2010), on the other hand, developed an SD model to examine interactions among landfill capacity, environmental impacts, and financial expenditure to better plan for urban waste management system in Newark, USA. Doan and Chinda (2016) developed the SD model to investigate the feasibility of construction and demolition waste recycling program in Bangkok. They concluded that the program worths the investment in 14 years with the minimum rate of return of 12%. Sukholthaman and Sharp (2016), developed an SD model to assess impacts of MSW separation in Thailand, and suggested a better condition for waste collection and transportation. Manasakunkit and Chinda (2017), similarly, developed a MSW dynamics model to examine MSW in Bangkok, Thailand, in the long-term. Nguyen and Chinda (2018) utilized the SD modeling approach to examine profit of residential projects in Ho Chi Minh City, Vietnam, and concluded that the average profit of the industry in the next 20 years will reach 35%, with a minimum and maximum percentages of 19% and 41%, respectively.

The dynamics model of food waste management is developed using the iThink software version 9.1.3. The model is constructed using four major components. Stock is a major accumulation, and flow is the rate of change in stock that can fill in or drain out the stock. Converter is an intermediate variable used for miscellaneous calculations, while connector is the information linked between cause and effect within the model structure (see Figure 3.2) (Chaerul et al., 2008).

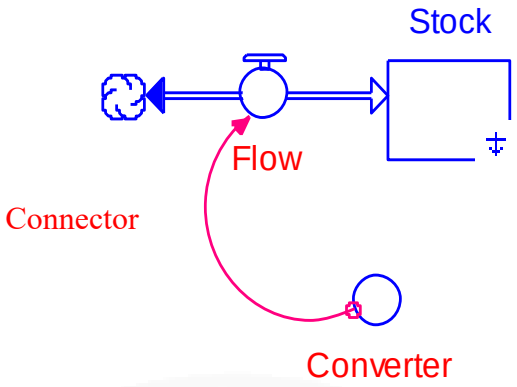

Figure 3.2 Components of the SD model

CHAPTER 4
DATA COLLECTION

4.1 General overview

This chapter describes the data collection, both secondary and primary data. Secondary data are achieved from a number of literatures, while primary data are collected from the interviews and site observations.

4.2 Secondary data collection

Secondary data are achieved from various sources, such as journal papers, company's reports, and websites. Examples of journal papers used for secondary data collection include Resources, Conservation and Recycling, Sustainability, Waste Management, and Waste Management & Research Journals. Popular websites related with Cambodian food and food waste management are also reviewed, such as Bongpet, Waste Management World, and World-Population-Review.

In this study, secondary data related with seven and five key factors affecting food waste are extracted based on household and retailer perspectives, respectively. Details are as the followings.

4.2.1 Secondary data: household perspectives

Seven key factors affecting food waste management for household sub-model development include 1) population, 2) family size, 3) family member, 4) shopping frequency, 5) price index, 6) food preparation, and 7) bio-digester. Secondary data are then collected to develop equations for the dynamics model of food waste management. World Population Review (2019), for example, mentioned that population increasing rate in Phnom Penh is around 0.0146% per year. NIS (2013), on the other hand, mentioned that more of small-sized families are expected in the near future, as its increasing rate is 2.7% per year. Aschemann-Witzel et al. (2015) added that different household sizes need different food portions. Small-sized families may need small portions; if only big size is available, this may cause food waste.

Table 4.1 summarizes the key secondary data based on household perspectives.

Table 4.1 Secondary data: household perspectives.

Factor	Description	Reference
Population	• With high growth rate, waste generation can be severed. • Initial population in Chamkamon and Duan Penh districts in 2018 = 308554 persons. • Population increasing rate = 0.0146% per year.	Pai et al. (2014), World Population Review (2019)
Family size	• Small-sized families increasing rate = 2.7% per year.	Demont and Heuveline, (2008), Sijab (2018)
Family member	• Members in a small-sized family can be up to three persons. • A large-sized family has at least four persons in a family.	Paul (2013), NIS (2013), Aschemann-Witzel et al. (2015)
Shopping frequency	• Common shopping frequencies are once a week, twice a week, and every day shopping.	Amanda (2016), Schanes et al. (2018)
Price index	• Vegetable price ranges from 1.04 to 1.65 USD per kg, on average.	Morone et al. (2016)
Food preparation	• Up to 11% of food waste occurs during food preparation processes.	Anirban (2016), Žitnik and Vidic (2016)
Bio-digester	• Use of bio-digester could save up to 57% of electricity cost. • Bio-digester has an average of 2-year life-span. • Investment cost of a bio-digester = 150 USD	Martí-Herrero (2008), CDC (2011), Romo-Rábago (2014)

Factor	Description	Reference
	• Electricity cost = 0.21 USD/kWh, on average. • Electricity generated by a bio-digester = 1.25 kWh/day, on average.	

4.2.2 Secondary data: retailer perspectives

Five factors affecting food waste management based on retailer perspectives include packing size, promotion, shelf-life, stock rotation, and order quantity. Packing sizes, promotion plan, and stock rotation method data are collected through secondary sources, and are used for the dynamics model development (see Table 4.2).

Table 4.2 Secondary data: retailer perspectives.

Factor	Description	Reference
Packing size	• 20–25% of food waste incurs due to mismatched packing sizes.	Aschemann-Witzel et al. (2015), Sharon (2017).
Promotion	• Various promotions can be used to increase sales, such as “buy 1 get 1 free”, “buy 4 get 1 free”, and “up to 75% off”.	Waste Management World (2015)
Shelf-life	• Shelf-life of one week is considered in this study to reflect the life-span of most vegetables.	Mena et al. (2011)
Stock rotation	• FIFO method is commonly used in the food industry.	Porta (2018), Arafa (2019), Shaun (2019)
Order quantity	• Different shops use different strategies to order the products. • Some common strategies include the use of last order quantity, matching demand and supply, and the use of safety stock to buffer the stock out.	Alsabrook (2016)

4.3 Primary data collection

Primary data are achieved from interviews and observations. Householders and a representative from retailers in Chamkamon and Daun Penh districts provide information for the dynamics model development. The interviewees were randomly selected from those who shop at the supermarkets. Interviewees are both males and females who regularly shop at the AEON MALL located in Chamkamon district. A total of 119 householders and one representative from the AEON MALL included in the interviews (see interview questions for householders and retailers in Appendices A and B, respectively). Their ages range from 20-35 years old. They provide data, such as shopping frequency, number of meals cooked per day, and their favorite ingredients. They also mentioned that most of their food waste are vegetables as they are cheap, and are always on promotion. A representative from retailers was also interviewed to gain in-depth information related to retailer's characteristics, such as order quantity, promotion plan, stock rotation method, and waste management policy.

4.3.1 Primary data: household perspectives

Primary data are collected, through household interviews, to be used for the dynamics model development. The data are based on four key factors, namely family size, family member, shopping frequency, and food preparation, while population, price index, and bio-digester factors use secondary data for the dynamics model development (see Table 4.3).

Table 4.3 Primary data: household perspectives.

Factor	Description
Family size	• 45% of respondents are from small-sized families, while 55% come from large-sized families.
Family member	• Members in a small-sized family = 3 persons. • Members in a large-sized family = 5 persons.
Shopping frequency	• Small-sized family shopping frequencies are separated as: o 19% for once a week shopping, o 58% for twice a week shopping, and o 23% for everyday shopping. • Large-sized family shopping frequencies are separated as: o 29% for once a week shopping, o 48% for twice a week shopping, and o 23% for everyday shopping.
Food preparation	• Most of interviewees cook one or two meals per day with one or two dishes per meal. • Most popular dishes are Lok Lak, Cha Tra Kuen, Trey Cha Cho Em, and Somlor Machou Kroeung. • Based on the popular dishes, the most used ingredients are cucumber, tomato, lettuce, morning glory, and carrot.

4.3.2 Primary data: retailer perspectives

Primary data, through interviews and observations, are also collected for three key factors affecting food waste management based on retailer perspectives, including packing size, promotion plan, and order quantity (see Table 4.4). Shelf-life and stock rotation factors, on the other hand, use secondary data for the dynamics model development.

Table 4.4 Primary data: retailer perspectives.

Factor	Description
Packing size	• Common packing sizes available at the retailers are 350g and 500g packs.
Promotion	• 55% of households mentioned that they would buy more food when they are on sales. • "Buy 4 get 1 free" promotion is commonly used at the supermarket, especially for fruits and vegetables.
Order quantity	• Order quantity in this study is based on household demand on vegetables and last order quantity.

In summary, 12 key factors affecting food waste management retrieve both secondary and primary data to be used to develop equations for the dynamics models of food waste management. Details are explained in Chapter 5.

CHAPTER 5
DEVELOPMENT OF THE SYSTEM DYNAMICS MODEL OF FOOD WASTE MANAGEMENT

5.1 General overview

This chapter develops model of food waste management utilizing the system dynamics modeling approach. Sensitivity analysis is performed to validate the development dynamics model. A number of strategies to reduce the amount of food waste in the long-term are also performed in this chapter.

5.2 Flow of dynamics model development

Population of Chamkamon and Daun Penh districts, in terms of number of households, are separated into small- and large-sized families. Each family may shop once a week, twice a week, or everyday. They may also cook once or twice a day (i.e. one or two meals per day), with different dishes per meal. These results in demand on vegetables per shopping. However, the amount shopped each time also depends on the price of the vegetables. When the vegetables price increases, the households may buy less (CBC, 2016). In this study, however, a constant price of 1 USD/kg is used in the dynamics model development to represent the average prices of the vegetables used in common dishes.

Household demand on vegetables is then the model of the demand matched with two available packing sizes, which are 250g and 500g packs, offered by the retailers. Number of purchased packs, however, might not be perfectly matched with the demand; this may result in “waste from inappropriate packing sizes”. Purchased vegetables may also turn to waste during cooking processes, resulting in “waste from preparation processes”.

Food waste may occur from promotion packs offered by the retailers. Households may not be able to consume promotion packs before their end-of-shelf-life, and that they are left as “waste from extra promotion packs”.

“Waste from inappropriate packing sizes”, “waste from preparation processes”, and “waste from extra promotion packs” are summed to achieved ‘household waste”. It is then combined with the “retailer waste”, mainly achieved from inappropriate order

quantity, to achieve the “total waste”. The bio-digesters may then be used, if worth the investment, to convert the “total waste” into energy. If the maximum capacity of bio digester is reached, the leftover waste, if any, is dumped into landfills.

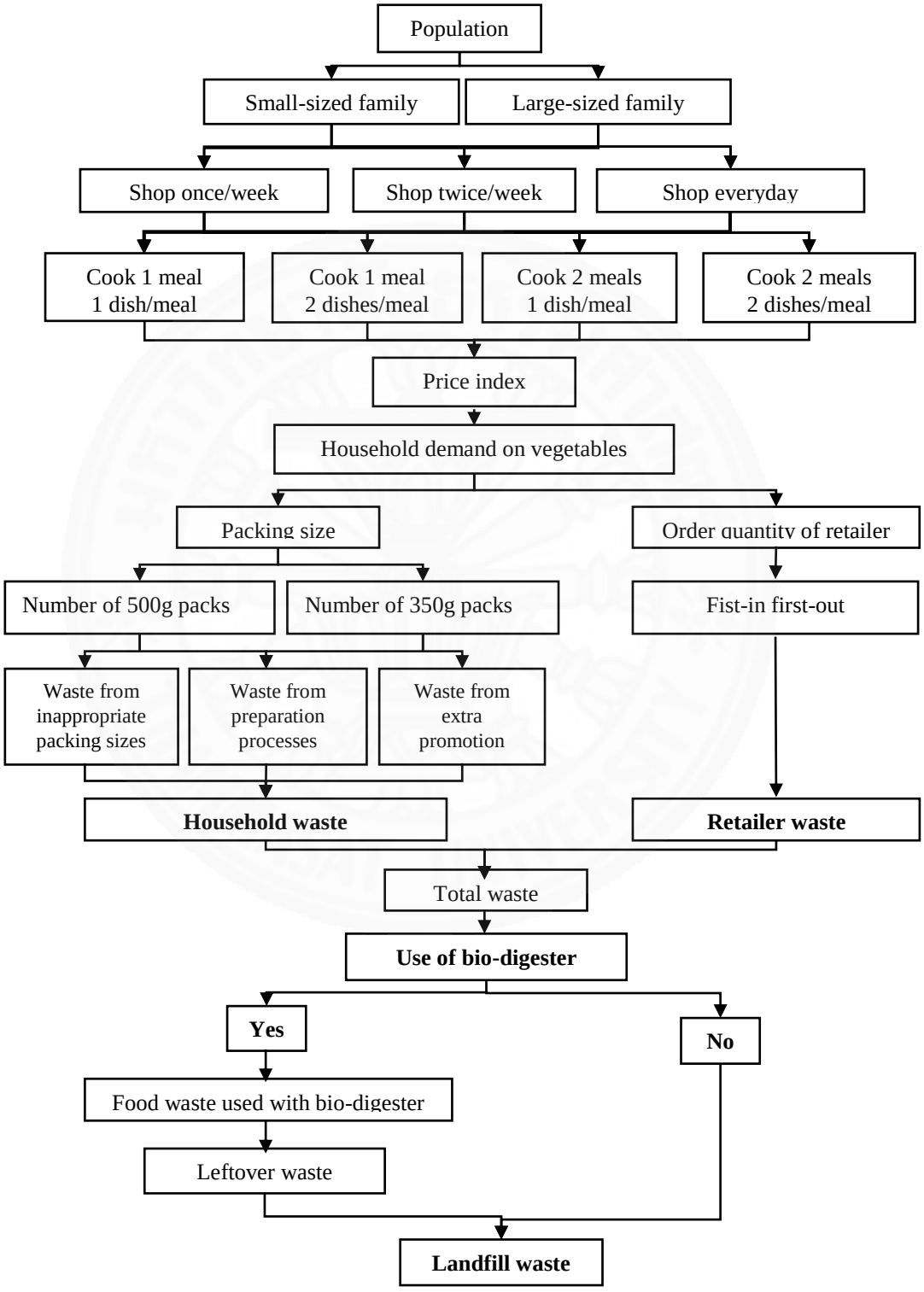

Figure 5.1 Flow of dynamics model of food waste management

5.3 Dynamics model of food waste management

In this study, the SD modelling approach is used to develop the dynamics model of food waste management in Phnom Penh, Cambodia. The model consists of three sub-models, including household waste, retailer waste, and bio-digester and landfill sub-models (see dynamics model food waste management in Appendices C-E). Flow of model development is as shown is Figure 5.1.

5.3.1 Household waste sub-model

Households are separated into small and large families. Each family has different shopping frequencies, including once a week, twice a week, and everyday shopping. These reflect the vegetable amount each family demands per shopping. The vegetable demand also depends on number of meals, as well as number of dishes, cooked per day. Based on the interviews, popular dishes that are usually cooked include Lok Lak, Cha Tra Kuen, Trey Cha Cho Em, and Somlor Machou Kroeung, leading to the cucumber, tomato, lettuce, morning glory, carrot, and capsicum demands. Equation (5.1) shows an example of vegetable demand for small family who shops everyday, cooks one meal per day, and cook only one dish per meal.

$$VNS711SF = AVD*C1T1D*SF \quad (5.1)$$

Where VNS711SF = Vegetable demand for small family who shops everyday, cooks one meal per day, and cooks only one dish per meal (g)
AVD = Average portion per dish per person (g)
C1T1D = Number of dishes cooked per day, i.e one dish per day based on one meal cooking per day and one dish cooked per meal (dish/meal)
SF = Small-size family members (persons)

Household demand on vegetables is matched with two packing sizes available at the retailer shops. Number of packs purchased are calculated to achieve the best match with the vegetable demand. These, however, may lead to “waste from

inappropriate packing sizes" if the demand is not perfectly matched with the packing sizes. Equation (5.2) shows an example of "waste from inappropriate packing sizes" of small family who shops everyday, cooks one meal per day, and cooks only one dish per meal. The only 350g packs, only 500g packs, and mixed of 350g and 500g packs are compared, and the packs with the lowest amount of waste is selected.

$$MWS711SF = MIN (W350S711SF, W500S711SF, WMPS711SF) \quad (5.2)$$

Where MWS711SF = Minimum waste from packing size for small family who shops everyday, cooks one meal per day, and cooks one dish per meal (g)

W350S711SF = Waste from 350g packing size only (g)

W500S711SF = Waste from 500g packing size only (g)

WMPS711SF = Waste from mixes of 350g and 500g packing sizes (g)

Food waste may also incur during cooking preparation processes. According to Žitnik and Vidic (2016), 11% of vegetable amount is wasted during food preparation, leading to "waste from preparation processes", as shown in equation (5.3).

$$WPS711SF = 0.11*VNS711SF \quad (5.3)$$

Where WPS711SF = Waste from preparation for small family who shops everyday, cooks one meal per day, and cooks only one dish per meal (g)

VNS711SF = Demand on vegetable for who shops everyday, cooks one meal per day, and cooks only one dish per meal (g)

Some retailers offer various promotions to attract customers. Some promotions, however, may result in "waste from extra promotion packs". In this study, the "buy-4 get 1 free" promotion results in more food wastes dumped into landfills. According to Žitnik and Vidic (2016), up to 64% of food may be thrown into landfills due to their short shelf-life. Therefore, 64% of promotion packs, in excess of household demands,

may be dumped into landfills. Among the consumed promotion packs, 11% of them may also be wasted during preparation processes, see equation (5.4).

$$TWEPS711SF = (PP*0.64) + (0.11*0.36*PP) \quad (5.4)$$

Where TWEPS711SF = Waste from promotion for small family who shops everyday, cooks one meal per day, and cooks only one dish per meal (g)

PP = Promotion packs (g)

The "Household waste", as shown in equation (5.5), is then a summation of the three wastes, including "waste from impropriate packing sizes", "waste from preparation processes", and "waste from extra promotion packs".

$$\text{Household waste} = MWS711SF + WPS711SF + TWEPS711SF \quad (5.5)$$

Where MWS711SF = Minimum waste from packing size for small family who shops everyday, cooks one meal per day, and cooks one dish per meal (g)

WPS711SF = Waste from preparation for small family who shops everyday, cooks one meal per day, and cooks only one dish per meal (g)

TWEPS711SF = Waste from promotion for small family who shops everyday, cooks one meal per day, and cooks only one dish per meal (g)

5.3.2 Retailer waste sub-model

The "household demand on vegetables" is used to manage the order quantities at the retailers. In this study, the new order is placed once a week to reflect an average shelf-life of vegetables of one week. The new order quantity depends on the "household demand on vegetables" and the order quantity last week. To explain, total vegetable

demand last week is compared with last week order quantity. If the vegetable demand last week is less than the last order quantity, then the new order quantity is equal to the last order quantity to satisfy the demand, and buffer for any demand uncertainties. In contrast, if the vegetable demand last week is higher than the last order quantity, then the new order quantity is set as last week vegetable demand to ensure enough supply to the householders, see equation (5.6 and 5.7).

NOQ = Max (Household demand on vegetables, Last week order quantity) (5.6)

LOQ = HISTORY (Household demand on vegetables, Time-7) (5.7)

Where NOQ = New order quantity (g)
LOQ = Last order quantity (g)

Food waste from retailers occurs when the buffer amount is not fully sold within a week (based on one-week shelf-life), see equation (5.8).

Retailer waste = Max (0, New order quantity – Household demand on vegetables) (5.8)

5.3.3 Bio-digester and landfill sub-model

Household and retailer wastes are summed to achieve the "total waste". In this study, the bio-digester is considered before transferring wastes to landfill. The use of bio-digester is based on assumption that saving in electricity cost, by using bio-digesters, is higher than the investment of the bio-digester system.

The "total waste" amount is used to calculate the total amount of bio-digesters needed in the system, see equation (5.9). They are, then, used to calculate the investment cost and electricity saving see equations (5.10), (5.11), and (5.12). The purchasing decision is then set when the saving is higher than the cost, see equation (5.13).

PNBD = Total waste/CBD (5.9)

TICW = PNBD*ICW (5.10)

ECSW = AEN*HH*0.57*0.21 (5.11)

MS = ECSW- TICW (5.12)

CSIC = IF MS >= 0 THEN 1 ELSE 0 (5.13)

Where PNBD = Number of bio-digester (unit)
CBD = Capacity of bio-digester (kg)
TICW = Total investment cost of bio-digester (USD)
PNBD = Number of bio-digester (unit)
ICW = Investment Cost (USD/unit)
ECSW = Electricity saving (USD)
AEN = Average electricity needed (kwh/week)
HH = Number of household (family)
MS = Saving amount of bio-digester investment cost (USD)
ECSW = Electricity saving (USD)
TICW = Total investment cost of bio-digester (USD)
CCSIC = Checking saving amount of bio-digester investment cost
1 = Yes
0 = N0

Once the bio-digesters are purchased, they are used for two years, reflecting their product life. During this period, no more bio-digesters are added in the system. Wastes, if over the bio-digester capacity, will be sent to landfills, see equations (5.14).

Landfill waste = Total waste – (PNBD*CBD) (5.14)

Where PNBD = Number of bio-digester (unit)
CBD = Capacity of bio-digester (kg)

5.4 Simulation results

The dynamics model of food waste management is simulated for one year period, and the simulation results are as shown in Figures 5.2. The results show that majority of wastes come from households. The "total waste" fluctuates during weeks due to two major reasons: the households who shop twice a week, and may be use leftover food before their expiry date, and the retailers that set the order quantity following the household demand. To explain, the households who shop twice a week may purchase vegetables at the beginning week. If they cannot consume all vegetables, they may consider purchasing less vegetables, and use FIFO strategy to manage the vegetables. This may result in less vegetables purchased in the middle of the week, and less food waste at the end of the week.

As the retailers order the vegetables based on the household demand, the fluctuation of waste from the retailers. These, then, lead to the fluctuation of "total waste" in Figure 5.2.

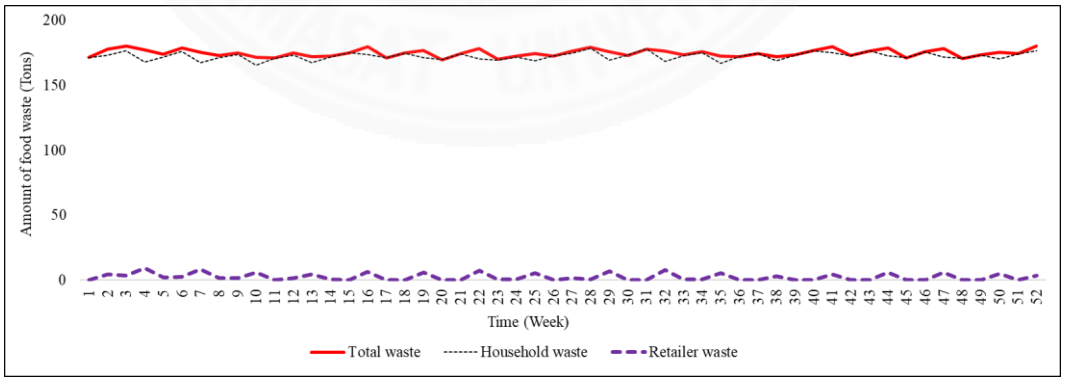

Figure 5.2 Total, household, and retailer food wastes.

Figure 5.3 shows three sources of household waste, namely “waste from preparation processes”, “waste from inappropriate packing sizes”, and “waste from extra promotion packs”. It is clear that majority of “household waste” comes from cooking processes.

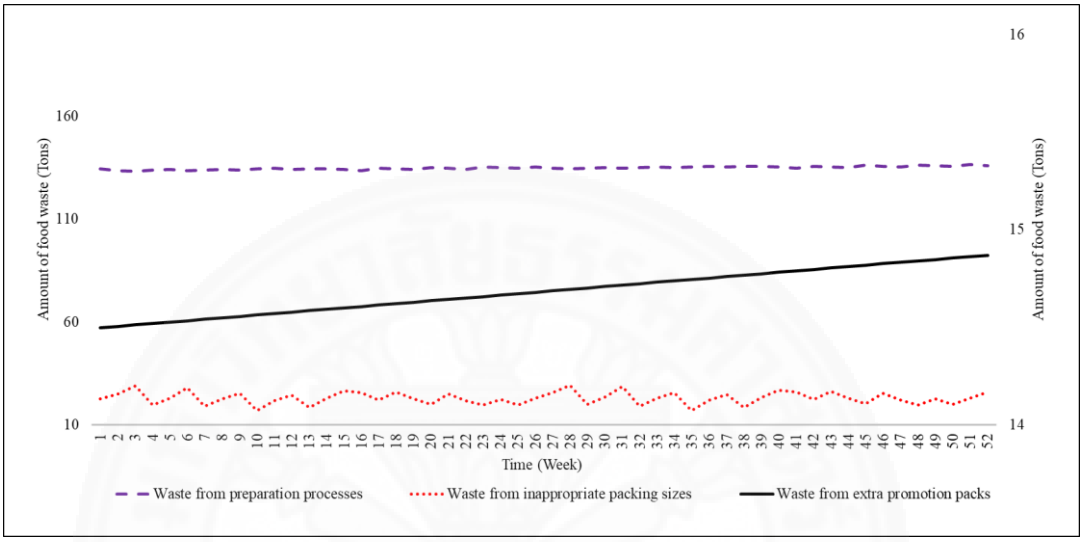

Figure 5.3 Wastes from preparation processes, inappropriate packing sizes, and extra promotion packs.

Table 5.1 shows the amount of household waste in each week. “Waste from preparation processes” takes up to six and nine times of “waste from inappropriate packing sizes” and “waste from extra promotion packs”, respectively. Knowledge on reducing waste during cooking processes is, therefore, needed to effectively use the vegetables, and reduce amount of waste going to landfills.

Table 5.1 Wastes from preparation processes, inappropriate packing sizes, and extra promotion packs.

Week	Amount of food waste (Tons)			Week	Amount of food waste (Tons)		
	Waste from preparation processes	Waste from inappropriate packing sizes	Waste from extra promotion packs		Waste from preparation processes	Waste from inappropriate packing sizes	Waste from extra promotion packs
1	134.51	22.56	14.49	27	134.81	25.42	14.68
2	133.73	25.06	14.50	28	134.47	29.29	14.69
3	133.41	28.79	14.51	29	134.85	19.81	14.69
4	133.78	19.63	14.51	30	135.26	23.30	14.70
5	134.19	22.98	14.52	31	134.88	28.45	14.71
6	133.58	28.02	14.53	32	135.08	18.93	14.72
7	134.00	18.82	14.53	33	135.41	22.81	14.72
8	134.31	22.57	14.54	34	135.11	25.52	14.73
9	134.04	25.12	14.55	35	135.53	16.77	14.74
10	134.45	16.71	14.56	36	135.60	21.93	14.75
11	134.73	21.76	14.56	37	135.34	24.65	14.75
12	134.26	24.32	14.57	38	135.67	18.39	14.76
13	134.57	18.32	14.58	39	135.59	23.20	14.77
14	134.51	22.89	14.59	40	135.33	26.76	14.78
15	134.27	26.31	14.59	41	134.95	25.75	14.78
16	133.66	25.44	14.60	42	135.82	22.30	14.79
17	134.73	22.07	14.61	43	135.48	26.25	14.80
18	134.40	25.88	14.62	44	135.18	22.79	14.80
19	134.11	22.50	14.62	45	136.28	20.14	14.81
20	135.19	19.95	14.63	46	135.67	25.36	14.82
21	134.81	25.05	14.64	47	135.41	21.88	14.83
22	134.34	21.66	14.64	48	136.44	19.59	14.83
23	135.33	19.48	14.65	49	136.13	22.39	14.84
24	135.04	22.11	14.66	50	135.87	19.78	14.85
25	134.79	19.60	14.67	51	136.62	22.97	14.86
26	135.28	22.77	14.67	52	135.89	25.79	14.86

By using bio-digesters, amount of food wastes dumped into landfills decrease, see Figure 5.4. The government may, therefore, need to motivate and support the local community to separate food wastes to be used with bio-digesters to save energy and reduce environmental impacts at landfills.

The simulation results show that the use of bio-digester is recommended, as saving electricity cost, achieved from the use of bio-digester, is higher than the investment cost of bio-digester system.

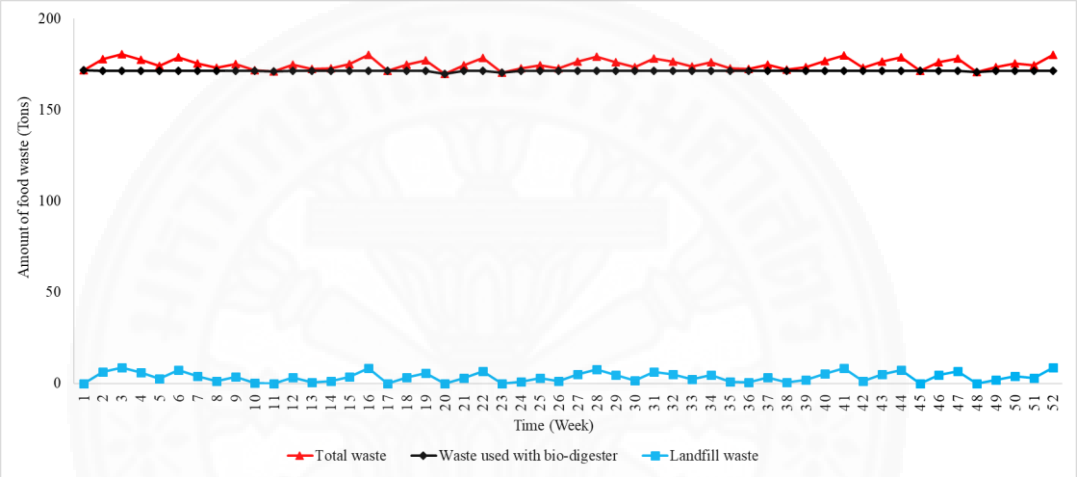

Figure 5.4 Total waste, waste used with bio-digesters, and landfill waste.

5.5 Summary of simulation results

The dynamics model of food waste management is run, and the simulation results suggested the use of bio-digesters to reduce the amount of food waste going to landfills. It is found that majority of waste comes from households. However, cooperation from retailers are also needed to, for example, properly management appropriate packing sizes that match with customer achieved, and have promotions that are suitable with customer need, and do not result in customer getting more vegetables than needed. The simulation results also show that no knowledge on cooking processes may results in high amount of waste. Local authority or government may assist in providing workshop to enhance the use of vegetables to reduce the amount of food waste in the long-term.

CHAPER 6
POLICY ANALYSIS

6.1 General overview

This chapter performs policy analyses to suggest a number of strategies to be used to decrease the amount of food waste in the long-term. The focus is on "household waste" as it is the majority of food waste, and that proper management is needed to reduce the amount of waste in the long-term.

6.2 Policy analysis of "waste from preparation processes"

The simulation results of the dynamics model of food waste management reveal that majority of household waste comes from cooking processes. According to Žitnik and Vidic (2016), waste occurs during food preparation can range from a minimum of 2% to a maximum of 11%. In this study, policy analysis is performed with 2%, 6.5%, and 11% of food preparation waste. The results, as shown in Figure 6.1 and Table 6.1, prove that with less percentage of waste in the preparation processes, food waste going to landfill decreases. The local authority, as well as government, may help in providing knowledge or guidelines on how to reduce waste in the preparation processes. Gustavsson et al. (2011), for example, suggested that householders should be educated in planning for menus in order to reduce the amount of food waste. Timmermans et al. (2014) commented that proper food portion should be considered before cooking, and a better food preparation technique is needed to avoid inedible food. HCED (2015) suggested tips to reduce food waste during preparation, such as the use of same ingredients when cooking more than one dish, and be cautious while cooking to avoid food drop and off-cuts. Kubala (2017) recommended the use of outer layers of carrots and cucumbers, as they are edible and nutritious.

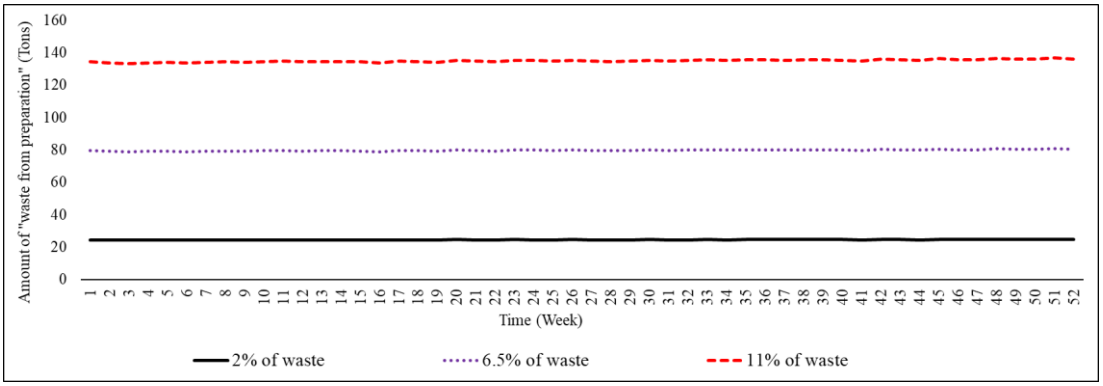

Figure 6.1 Simulation results of "waste from preparation processes" when different percentages of waste occurred in the preparation processes.

Table 6.1 Simulation results of "waste from preparation processes"

Week	Amount of waste with different percentages of food preparation waste (Tons)			Week	Amount of waste with different percentages of food preparation waste (Tons)		
	2%	6.5%	11%		2%	6.5%	11%
1	24.45	79.48	134.51	27	24.51	79.66	134.81
2	24.31	79.02	133.73	28	24.45	79.46	134.47
3	24.25	78.83	133.41	29	24.51	79.68	134.85
4	24.32	79.05	133.78	30	24.59	79.93	135.26
5	24.39	79.29	134.19	31	24.52	79.70	134.88
6	24.28	78.93	133.58	32	24.56	79.82	135.07
7	24.36	79.18	134.01	33	24.62	80.01	135.41
8	24.42	79.37	134.31	34	24.56	79.84	135.11
9	24.37	79.20	134.04	35	24.64	80.09	135.53
10	24.44	79.45	134.45	36	24.65	80.12	135.60
11	24.49	79.61	134.73	37	24.60	79.97	135.34
12	24.41	79.33	134.26	38	24.66	80.17	135.67
13	24.46	79.52	134.57	39	24.65	80.12	135.59
14	24.45	79.48	134.51	40	24.60	79.97	135.33
15	24.41	79.34	134.27	41	24.53	79.74	134.95
16	24.30	78.98	133.66	42	24.69	80.26	135.82
17	24.49	79.61	134.73	43	24.63	80.05	135.48
18	24.43	79.41	134.40	44	24.57	79.88	135.18
19	24.38	79.25	134.11	45	24.77	80.53	136.28
20	24.58	79.88	135.19	46	24.66	80.17	135.67
21	24.51	79.69	134.81	47	24.62	80.01	135.41
22	24.42	79.38	134.34	48	24.80	80.62	136.44
23	24.60	79.96	135.33	49	24.75	80.44	136.13
24	24.55	79.79	135.04	50	24.70	80.28	135.87
25	24.50	79.65	134.79	51	24.84	80.73	136.62
26	24.59	79.94	135.28	52	24.70	80.30	135.89

6.3 Policy analysis of "waste from inappropriate packing sizes"

Based on the retailer interviews, possible packing sizes, ranging from 250g to 1 kg, are simulated to suggest the best packing sizes used by the retailers to match with customer demand. The results, as shown in Figure 6.2 and Table 6.2, illustrate that with small packing sizes of 250g and 350g packs, food wastes going to landfill decrease. Retailers may, therefore, consider using the 250g and 350g packs to reduce the amount of food waste. This, however, may increase other types of waste, such as foam and plastic, as more packs are needed for each household. The government may, instead, promote the use of recycled paper bags, or encourage householders to bring their own bags to reduce the amount of undegradable plastic and foam going to landfills. The government may also initiate "no plastic bag" day to raise concern on plastic problems to the environment.

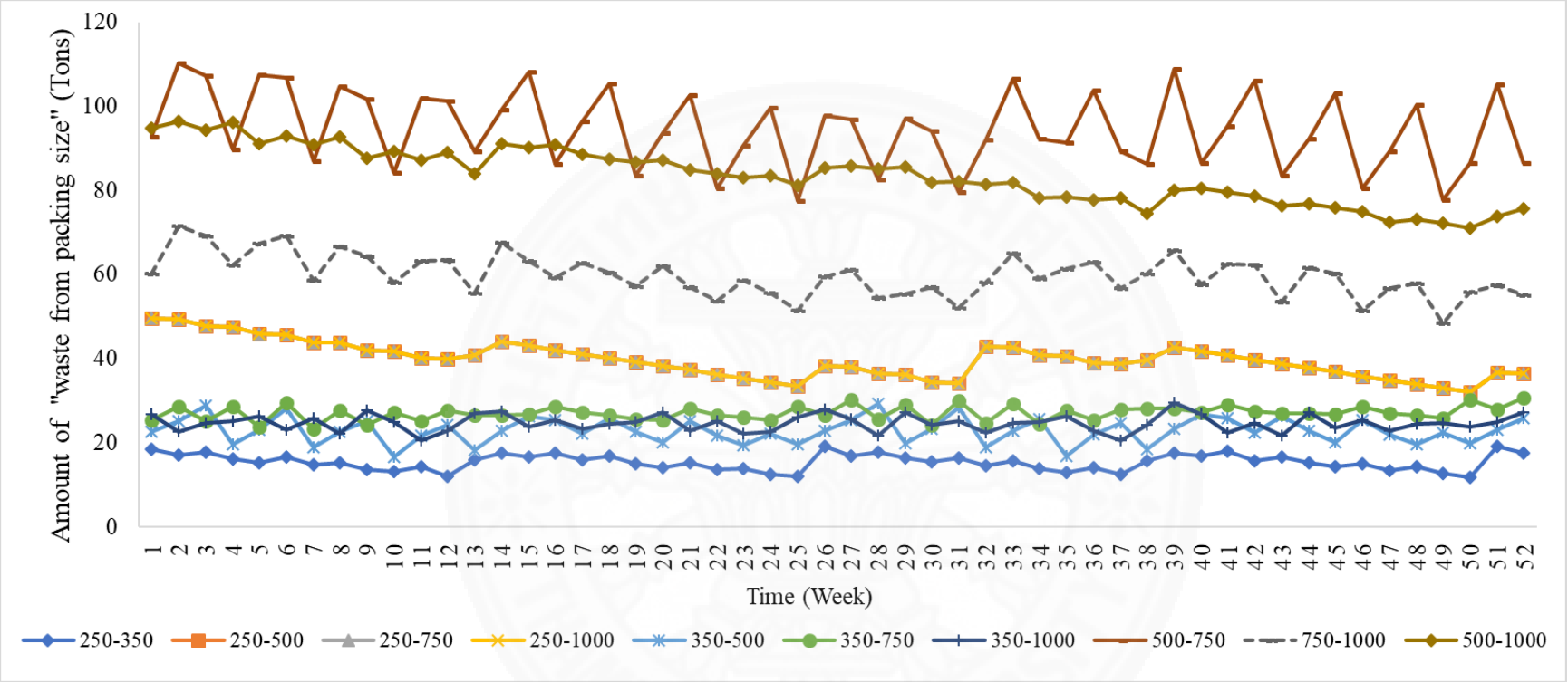

Figure 6.2 Simulation results of "waste from inappropriate packing sizes" when different packing sizes are considered.

Table 6.2 Simulation results of "waste from inappropriate packing sizes"

Week	Amount of waste with different packing sizes (Tons)									
	250&350	250&500	250&750	250&1000	350&500	350&750	350&1000	500&750	500&1000	750&1000
1	18.48	49.57	49.57	49.57	22.56	25.33	26.68	92.61	94.66	60.17
2	16.98	49.38	49.38	49.38	25.06	28.68	22.54	110.28	96.46	71.55
3	17.88	47.69	47.69	47.69	28.80	25.25	24.67	107.17	94.40	69.22
4	16.22	47.50	47.50	47.50	19.63	28.53	25.16	89.77	96.20	62.15
5	15.13	45.80	45.80	45.80	22.99	23.84	26.40	107.51	91.11	67.34
6	16.51	45.62	45.62	45.62	28.03	29.53	23.15	106.67	92.91	69.10
7	14.75	43.92	43.92	43.92	18.82	23.33	25.91	86.93	90.84	58.57
8	15.12	43.73	43.73	43.73	22.58	27.70	22.20	104.72	92.63	66.69
9	13.59	42.03	42.03	42.03	25.12	24.16	27.63	101.63	87.55	64.35
10	13.14	41.83	41.83	41.83	16.71	27.30	24.81	84.07	89.34	58.00
11	14.25	40.14	40.14	40.14	21.76	25.13	20.64	101.94	87.26	63.22
12	11.97	39.94	39.94	39.94	24.32	27.56	22.78	101.10	89.05	63.47
13	15.97	40.88	40.88	40.88	18.32	26.63	27.00	89.14	83.97	55.54
14	17.55	43.96	43.96	43.96	22.90	26.63	27.42	99.14	91.05	67.61
15	16.59	43.01	43.01	43.01	26.31	26.84	23.69	108.15	90.24	63.26
16	17.44	42.05	42.05	42.05	25.44	28.60	25.43	86.26	90.74	59.37
17	15.81	41.10	41.10	41.10	22.07	27.10	23.20	96.34	88.43	62.72
18	16.81	40.14	40.14	40.14	25.89	26.56	24.51	105.32	87.44	60.44
19	15.02	39.18	39.18	39.18	22.51	25.55	24.90	83.36	86.62	57.11
20	14.06	38.22	38.22	38.22	19.96	25.36	27.10	93.53	87.12	62.03
21	15.28	37.27	37.27	37.27	25.06	28.13	22.91	102.50	84.81	57.04
22	13.64	36.31	36.31	36.31	21.67	26.62	25.09	80.47	83.82	53.62
23	13.86	35.34	35.34	35.34	19.49	26.08	22.23	90.72	82.99	58.50
24	12.45	34.38	34.38	34.38	22.12	25.47	22.59	99.66	83.49	55.49
25	12.00	33.42	33.42	33.42	19.61	28.70	26.00	77.56	81.17	51.33
26	19.17	38.32	38.32	38.32	22.77	26.62	27.80	97.65	85.42	59.55
27	16.92	38.10	38.10	38.10	25.43	30.19	25.52	96.82	85.84	61.06
28	17.77	36.39	36.39	36.39	29.30	25.59	21.76	82.49	85.08	54.34
29	16.50	36.16	36.16	36.16	19.81	29.04	27.21	97.02	85.49	55.25
30	15.39	34.45	34.45	34.45	23.31	24.18	24.32	93.96	81.76	56.84
31	16.35	34.21	34.21	34.21	28.46	29.97	25.25	79.55	82.17	52.11
32	14.58	42.82	42.82	42.82	18.93	24.62	22.32	91.93	81.41	58.10
33	15.69	42.60	42.60	42.60	22.82	29.18	24.59	106.61	81.80	65.08
34	13.76	40.91	40.91	40.91	25.52	24.48	24.88	92.14	78.09	58.96
35	12.93	40.69	40.69	40.69	16.77	27.77	26.27	91.28	78.48	61.31
36	13.98	38.99	38.99	38.99	21.94	25.39	22.92	103.82	77.72	62.91
37	12.47	38.77	38.77	38.77	24.65	28.00	20.60	89.26	78.11	56.65
38	15.79	39.66	39.66	39.66	18.39	28.08	24.12	86.19	74.40	60.15
39	17.50	42.65	42.65	42.65	23.20	28.10	29.61	108.79	79.97	65.80
40	16.90	41.68	41.68	41.68	26.76	27.29	26.68	86.37	80.46	57.66
41	18.09	40.71	40.71	40.71	25.76	29.00	22.43	95.15	79.57	62.51
42	15.70	39.74	39.74	39.74	22.31	27.51	24.70	105.97	78.60	62.24
43	16.66	38.78	38.78	38.78	26.26	26.96	21.76	83.48	76.24	53.45
44	15.25	37.80	37.80	37.80	22.80	26.97	27.25	92.24	76.73	61.56
45	14.27	36.83	36.83	36.83	20.15	26.81	23.43	103.14	75.84	60.12
46	15.06	35.86	35.86	35.86	25.36	28.50	25.31	80.57	74.86	51.33
47	13.43	34.89	34.89	34.89	21.89	27.02	22.95	89.32	72.50	56.72
48	14.37	33.91	33.91	33.91	19.60	26.45	24.41	100.30	72.99	57.92
49	12.58	32.94	32.94	32.94	22.39	25.84	24.61	77.67	72.09	48.34
50	11.74	31.96	31.96	31.96	19.79	30.28	23.80	86.39	71.12	55.76
51	19.10	36.74	36.74	36.74	22.98	28.00	24.84	105.16	73.88	57.50
52	17.62	36.48	36.48	36.48	25.79	30.71	27.16	86.48	75.61	55.04

6.4 Policy analysis of "waste from extra promotion packs"

According to the retailer interviews, there are various promotions, such as 10%, 25%, and 50% off-price. In this study, policy analysis is performed with 10%, 25%, and 50% off-price promotions. The results, as shown in Figure 6.3 and Table 6.3, illustrate that 50% off-price promotion, or buy 1 get 1 free, results in the highest amount of food waste going to landfills. This is consistent with Timmermans et al. (2014) that advance purchasing of food that is not required immediately may result in more wastes. Planning for advanced purchases is important to reduce food waste (Wes, 2015).

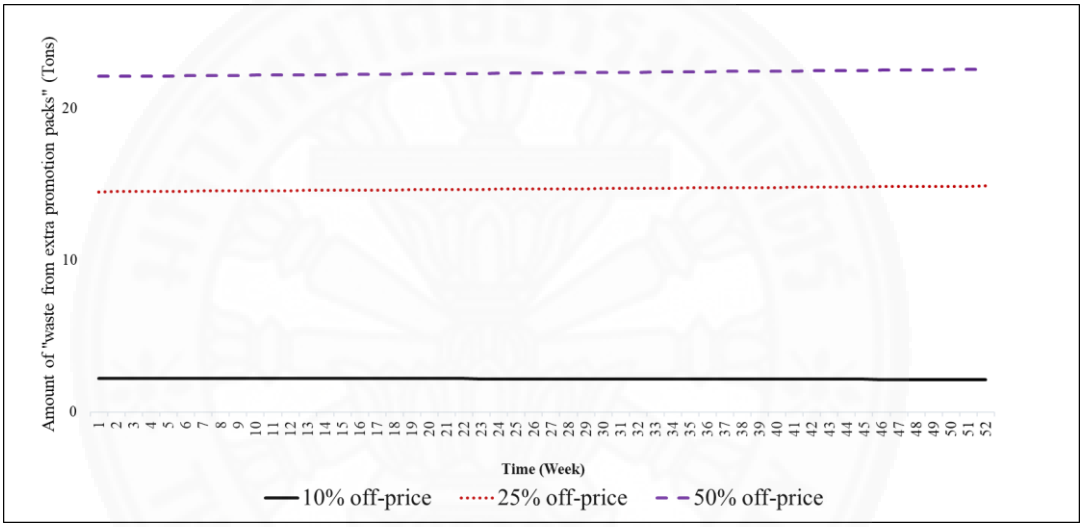

Figure 6.3 Simulation results of "waste from extra promotion packs" when different promotions are considered.

Table 6.3 Simulation results of "waste from extra promotion packs"

Week	Amount of waste with different promotions (Tons)			Week	Amount of waste with different promotions (Tons)		
	10% off-price	25% off-price	50% off-price		10% off-price	25% off-price	50% off-price
1	2.23	14.50	22.08	27	2.18	14.68	22.32
2	2.23	14.50	22.09	28	2.18	14.69	22.33
3	2.22	14.51	22.10	29	2.18	14.70	22.33
4	2.22	14.52	22.11	30	2.18	14.71	22.34
5	2.22	14.53	22.12	31	2.18	14.71	22.35
6	2.22	14.53	22.13	32	2.17	14.72	22.36
7	2.22	14.54	22.14	33	2.17	14.73	22.37
8	2.21	14.55	22.15	34	2.17	14.74	22.38
9	2.21	14.55	22.15	35	2.17	14.74	22.39
10	2.21	14.56	22.16	36	2.17	14.75	22.40
11	2.21	14.57	22.17	37	2.17	14.76	22.41
12	2.21	14.58	22.18	38	2.16	14.77	22.42
13	2.21	14.58	22.19	39	2.16	14.77	22.42
14	2.20	14.59	22.20	40	2.16	14.78	22.44
15	2.20	14.60	22.21	41	2.16	14.79	22.44
16	2.20	14.61	22.22	42	2.16	14.79	22.45
17	2.20	14.61	22.23	43	2.15	14.80	22.46
18	2.20	14.62	22.24	44	2.15	14.81	22.47
19	2.20	14.63	22.25	45	2.15	14.82	22.48
20	2.19	14.63	22.25	46	2.15	14.82	22.49
21	2.19	14.64	22.26	47	2.15	14.83	22.50
22	2.19	14.65	22.27	48	2.15	14.84	22.51
23	2.19	14.66	22.28	49	2.14	14.85	22.52
24	2.19	14.66	22.29	50	2.14	14.85	22.53
25	2.19	14.67	22.30	51	2.14	14.86	22.54
26	2.18	14.68	22.31	52	2.14	14.87	22.54

6.5 Summary of policy analyses

Policy analyses to reduce the amount of food waste are performed, mainly with "household waste" to investigate the amount of waste going to landfills in the long-term. The simulation results suggest the following strategies:

- Reduce in "waste from preparation processes" helps reduce food waste amount. Local authority and government may help in providing basic cooking knowledge to households, such as the effective use of vegetables, cooking without burning, and use of leftover food to make new dishes, and raising concerns on food waste problems to get cooperation from households to reduce waste.
- Appropriate packing sizes are needed to reduce food waste. Cooperation between households and retailers is crucial to match the demand and supply. Market survey or customer feedback may be used to achieve the correct packing sizes. The smaller packing sizes, on one hand, may reduce the amount of food waste, but on the other hand, may increase packaging wastes. The use of environmentally friendly packages must be considered to effectively manage landfill waste in the long-term.
- Communication between retailers and householders is also needed regarding the available promotions at the shops. Announcement of the next promotion in advance may help householders to plan for food purchasing, and cook all vegetables before their expiry dates.

The above strategies help community to reduce the amount of food waste. Cooperation between households and retailers is necessary to effectively plan for food waste management in the long-term.

CHAPER 7
CONCLUSION

7.1 General overview

This chapter presents major findings of this research study. Contributions to the area of study (i.e. Food waste management) are explained. Limitations and recommendations for future research are also stated at the end of this chapter.

7.2 Major findings

Food waste is becoming a serious problem in Phnom Penh, as more wastes are dumped into landfill, causing landfill shortage and a number of environmental problems.

This study utilizes the system dynamics modelling approach to develop the dynamics model of food waste management to investigate the trend of food waste in Phnom Penh, Cambodia in the long-term. The developed dynamics model considers two major sources of waste, namely households and retailers with a total of 12 factors affecting food waste. Seven key factors including, population, family size, family member, shopping frequency, price index, food preparation, and bio-digester are extracted based on household perspectives, while five factors, namely packing size, promotion, shelf-life, stock rotation, and order quantity listed based on retailer perspectives. Secondary and primary data are then collected through a number of sources. A total of 119 and a representative from the retailer householders from Chamkamon and Daun Penh districts are interviewed to provide necessary data, such as shopping frequencies, favorite ingredients, family members, packing sizes, and promotion schemes.

The collected data are then used to develop equations for the dynamics model of food waste management. The model is simulated, and the simulation results reveal that households are major source of food waste. The majority of household wastes occur during food preparation processes, and from mismatches of packing sizes, unfinished promotion packs, respectively. Retailers, on the other hand, mainly generate from the inappropriate order quantity.

Policy analysis is future performed to suggest a number of strategies to be used to reduce the amount of food waste in the long-term. Such as the followings:

- Local authority and government should play a key role to provide basic cooking knowledge to households, such as the effective use of fruits and vegetables and reduction of leftover food to avoid unnecessary waste during cooking processes.
- Appropriate packing sizes help reduce food waste. As more of small-sized families are expected increase in the future, the use of smaller packing sizes must be considered. The cooperation between households and retailers are crucial to effectively match the demand and supply. Moreover, the use of environmentally friendly packages, such as degradable plastic and paper bags must be considered to reduce other types of waste, apart from food waste, in the long-term.
- Promotions on food products at shop should be announce in advance, so that householders can plan ahead for food portion needed in the shopping.
- The use of bio-digesters is recommended in the community, with the cooperation from households, retailers, local authority, and government. Basic knowledge of bio-digester, such as the operation methods, the safety measures, and the benefits of the system should be promoted to effectively implement the system in the long-term.
- Retailers should perform the market survey to match the customer demand and supply. Doing this, the retailers can match types and amount of vegetables to be ordered each time, and minimize the amount food waste going to landfills.

The above strategies assist households, retailers, local authority, and government to effectively plan for food waste management, and reduce the amount of landfill waste on the long-term.

7.3 Contribution to the area of study

The dynamics model of food waste management contributes to food waste management in the following areas:

- Most of pervious studies examine factors affecting food waste management to reduce the environmental-related problems. However, their interaction and

feedback are rarely studied. This research study develops the dynamics model of food waste management with the interactions among 12 factors affecting food waste management and their feedback in the long-term. The trend of food waste and landfill waste can be investigated through the developed dynamics model, thus providing guidelines for food waste management in the long-term.

- The SD modelling approach is used to develop the dynamics model in an easy format using stocks, flows, converters, and connectors. The simulation results can also be displayed in both tables and graphs, thus making it easy to understand.
- The policy analysis, performed through the developed of dynamics model, suggests a number of strategies to be used to reduce the amount of food waste in the long-term, by focusing on householders, retailers, local authority, and government.

7.4 Limitations and recommendations for future research

This study has some limitations.

- Vegetables are the major source of food waste in this study, and that they base mainly on popular dishes. Fruits, meats, and other types of food may be considered to cover various types of food waste.
- Open market is not considered in this study, as it is hard to measure exact amount of waste.
- The price of vegetables used in the study is constant. Various prices may be considered for various vegetables to reflect real cost. This, however, may increase the complication of the dynamics model.
- Only one promotion scheme, which is “buy 4 get 1 free,” is used in this study. Other possible promotions may be simulated to examine the amount of food waste, and suggest appropriate promotions to be used in the supermarkets.
- Different sizes and prices of the bio-digesters may be considered based on population size of this study.

7.5 Closure

The dynamics model of the food waste management pinpoints the areas of food waste management through households and retailers perspectives, and suggest a number strategies to manage food waste and reduce amount of waste going to landfills in the long-term.

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APPENDICES

APPENDICES A

INTERVIEW QUESTIONS FOR HOUSEHOLD

Sample Number……

1. How many members live together in your home? ..... persons

2. What is average income of your family in your home?
   - ☐ Less than 4,153,946.52KHR (person/year)
   - ☐ 4,156,305.30KHR to 16,346,974.77KHR (person/year)
   - ☐ 16,346,633.88KHR to 50,547,326.38KHR (person/year)
   - ☐ More than 50,532,938.19KHR (person/year)

3. How often do you go to shop?
   - ☐ Everyday ☐ Twin a week
   - ☐ Once a week ☐ Others.....

   Please state reasons?
   - ☐ Distance ☐ Time ☐ Budget
   - ☐ Cooking style ☐ Others.....

4. What kind of food do you usually buy?
   - ☐ Fresh ingredient to be cooked (go to Q5) ☐ Cooked food (go to Q6)
   - ☐ Home delivery Fast food (go to Q6) ☐ Others.....

5. What is your favorite food? (choose only one in each type)

   5.1 Vegetable:

☐ Carrot	☐ Cucumber	☐ Daikon	☐ Eggplants
☐ Tomato	☐ Lime	☐ Oinion	☐ lettuce
☐ Morning Glory	☐ Potato	☐ Capsicums	☐ Winter melon
☐ Seamless online	☐ Pumpkin	☐ Green Papaya	☐ French bean
☐ Greem jack fruit	☐ Green banana	☐ Pineapple	☐ Mushroom

5.2 Fruit:

☐ Banana ☐ Longan ☐ Druin ☐ Jackfruit

☐ Water melon ☐ Pine apple ☐ Guava ☐ Milk fruit

☐ Mango ☐ Dragon fruit ☐ Capsicums ☐ Winter melon

5.3 Meat:

☐ Chicken ☐ Beef ☐ Fish ☐ Sea food

5.4 Daily and egg:

☐ Eggs ☐ Milk ☐ Bread

5.5 Cooked food:

☐ Chicken grilled ☐ Salands ☐ Fired rice ☐ Fired noodle

6. What food do you normally cook or order?

☐ LOK LAK ☐ TREY CHA CHO EM

☐ CHA TRA KUEN ☐ SNGOR CHROK

☐ SAMLOR MACHU KREUNG ☐ KHOR SACH CHROUK

☐ KROKO ☐ SOMLOR MACHOU YOUN

Apart from the above 8 dishes, what are other dishes you cook at home?

……

7. How often do you cook or order?

☐ Only breakest ☐ Only lunch ☐ Only dinner

☐ Breakfast and dinner ☐ Lunch and dinner ☐ Breakfast and Lunch

☐ Breakfast and Lunch and dinner

8. How many dishes do you normally cook or order per day?.....per day.

9. Do you always buy or order the same brand name of food?

☐ Yes ☐ No

10. Will you buy/ order extra amount when it is on sale?

☐ Yes ☐ No

11. Have you always thrown away the food?

☐ Yes ☐ No

If yes: If yes: How many percentage do you throw away on average?..... %

If no, what is your strategy?

☐ Combining cook ☐Use storage method ☐Others.....

12. Do you always have a plan before you go shopping?

☐ Yes ☐No

If No: What decision do you use in shopping?

☐ Buy discount products ☐Buy commoncooked food ☐Others.....

13. How do you feel with packing size available at the store?

☐ Satisty ☐ Unsatisty

If unsatify: ☐ the size is too bug

☐ the size is too small

14. What is common packing size you buy?

14.1 Vegetable

☐ 0.5 kg ☐ 1 kg ☐ 1.5 kg ☐ 2 kg ☐ Others.....

14.2 Fruit

☐ 0.5 kg ☐1 kg ☐ 1.5 kg ☐ 2 kg ☐ Others.....

14.3 Meat

☐ 0.25 kg ☐ 0.5 kg ☐ 0.75 kg ☐ 1 kg ☐ Others.....

14.4 Dairy and egg

14.4.1 Dairy

☐ 2 eggs ☐12 eggs ☐ Others.....

14.4.2 Egg

☐ 400 ml ☐ 830 ml ☐1litre ☐ 1,5 litres ☐ 2 litres

14.5 Cooked food

☐ A box for one person ☐ A box for 2 persons

☐ Others.....

15. What is common storage method you use?

☐ Put in refrigerator ☐ Leave it out side ☐ Others.....

16. Do you cook or order extra amount of food in festival season?

☐ Yes ☐ No

If no, why

☐ Eat outside ☐ Not celerbrate ☐ Others.....

17. What do you normally do with food waste?

☐ Throw away ☐ Composed ☐ Feed the animal ☐ Others.....

18. Does your community have a plan to manage food waste?

☐ Yes ☐ No

If yes: what is the plan?.....

APPENDIX B
INTERVIEW QUESTIONS FOR RETAILER

1. What is your position?

2. What types of food are available in your shop? (choose more than one)

   ☐ Vegetables ☐ Fruits ☐ Meats

   ☐ Dairy and eggs ☐ Cooked food

3. What are the common packing sizes for each food type available in your shop? (you can choose more than one)

   3.1 Vegetable:

   ☐ 0.5 kg ☐ 1 kg ☐ 1.5 kg ☐ 2 kg ☐ Others.....

   3.2 Fruit:

   ☐ 0.5 kg ☐ 1 kg ☐ 1.5 kg ☐ 2 kg ☐ Others.....

   3.3 Meat:

   ☐ 0.25 kg ☐ 0.5 kg ☐ 0.450g ☐ 0.75 kg ☐ Others.....

   3.4 Daily and eggs:

   3.4.1 Dairy

   ☐ 2eggs ☐ 12 eggs ☐ Others.....

   3.4.2 Egg

   ☐ 400 ml ☐ 830 ml ☐ 1 litre ☐ 1,5 literes ☐ 2 literes

   3.5 Cooked food:

   ☐ A box for one person ☐ A box for 2 people

   ☐ Others.....

4. How do you plan for ordering amount?

   ☐ Use previous sale amounts ☐ Consider price at the moment

   ☐ Others.....

5. Please rank <u>top three</u> common strategies/promotions used in your shop?

☐ Buy one get one free ☐ Promotion on the last expiry date product

☐ Monthly promotion ☐ Promotion on **festive season**

☐ Others.....

5.1 Vegetable:

……

……

……

5.2 Fruit:

……

……

……

5.3 Meat:

……

……

……

5.4 Daily and egg:

……

……

……

5.5 Cooked food:

……

……

……

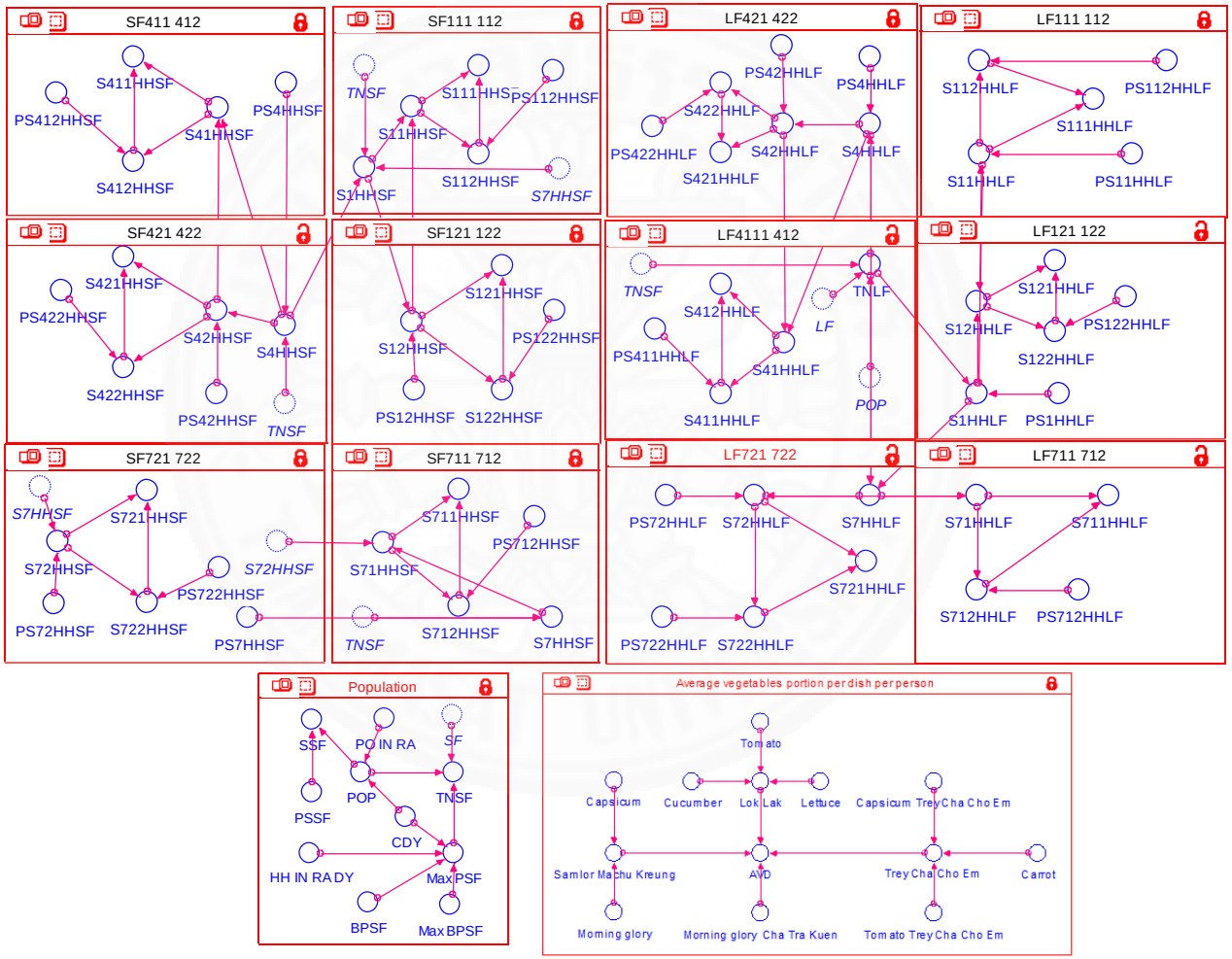
6. Do you have food waste policies?

……

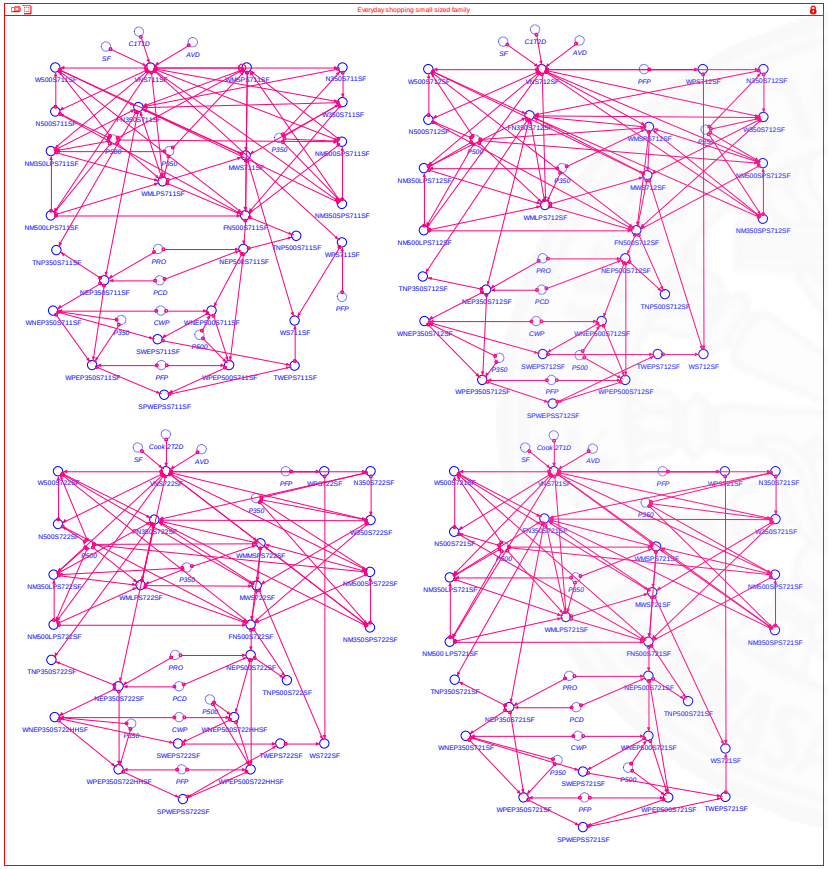
……

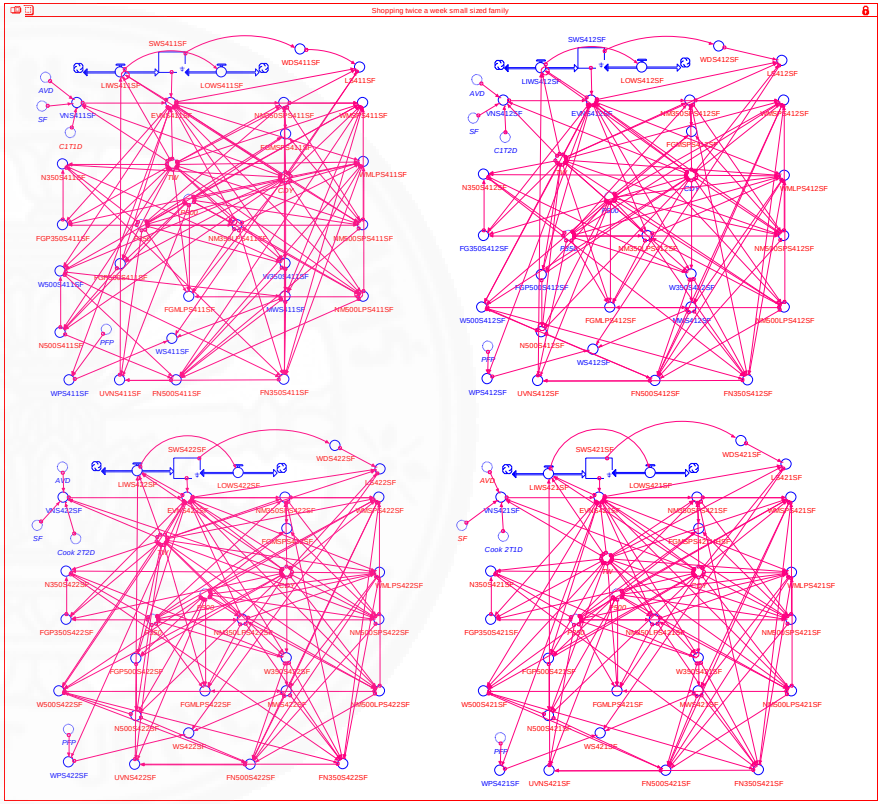
……

APPENDIX C
HOUSEHOLD SUB-MODEL

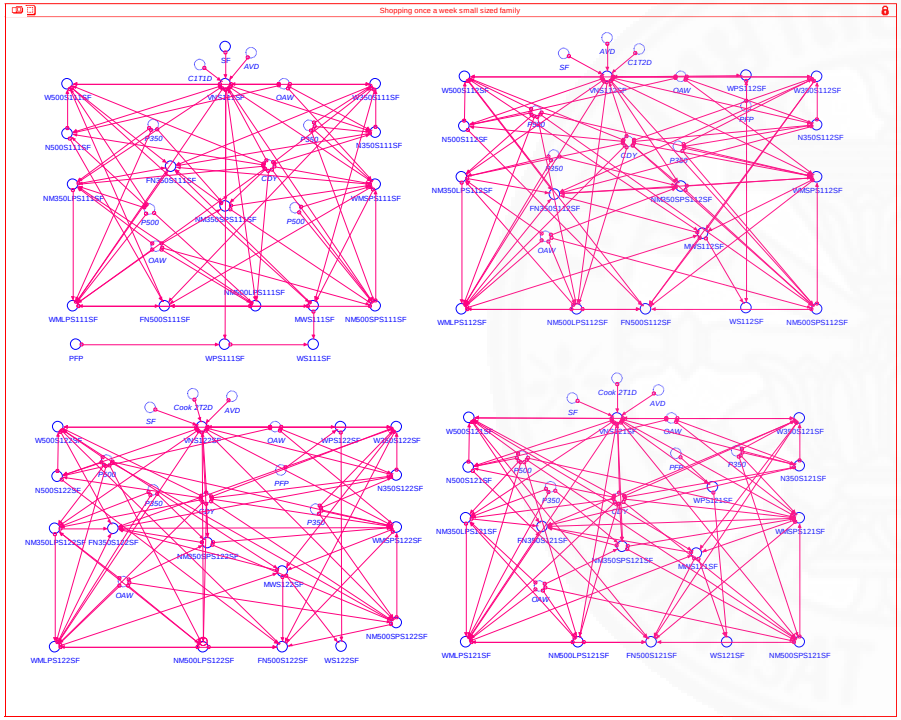


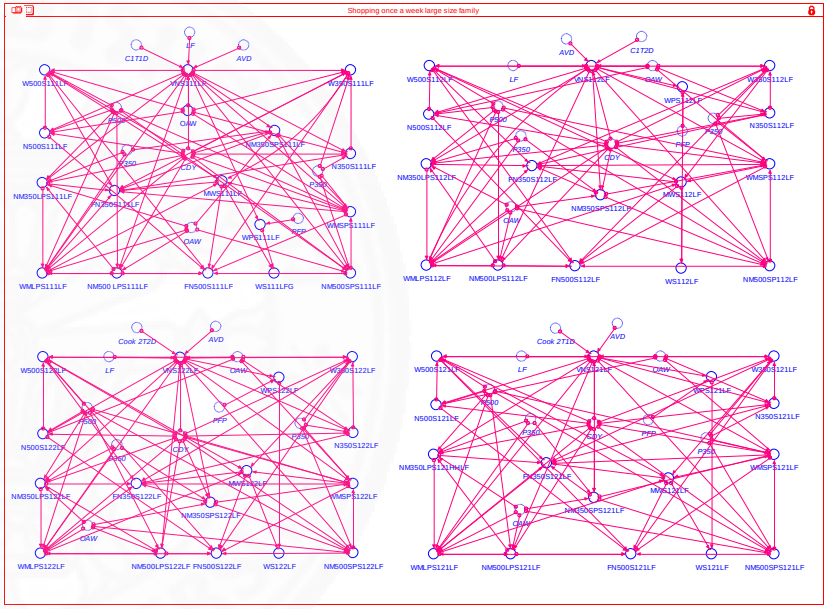
APPENDIX C
HOUSEHOLD SUB-MODEL



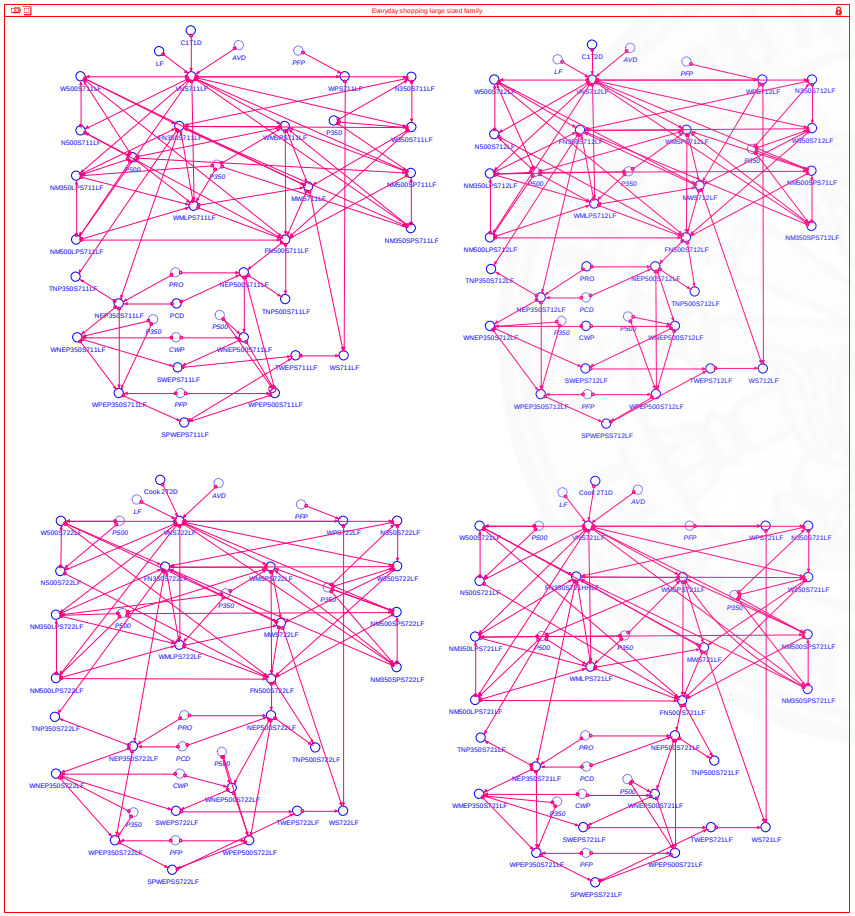


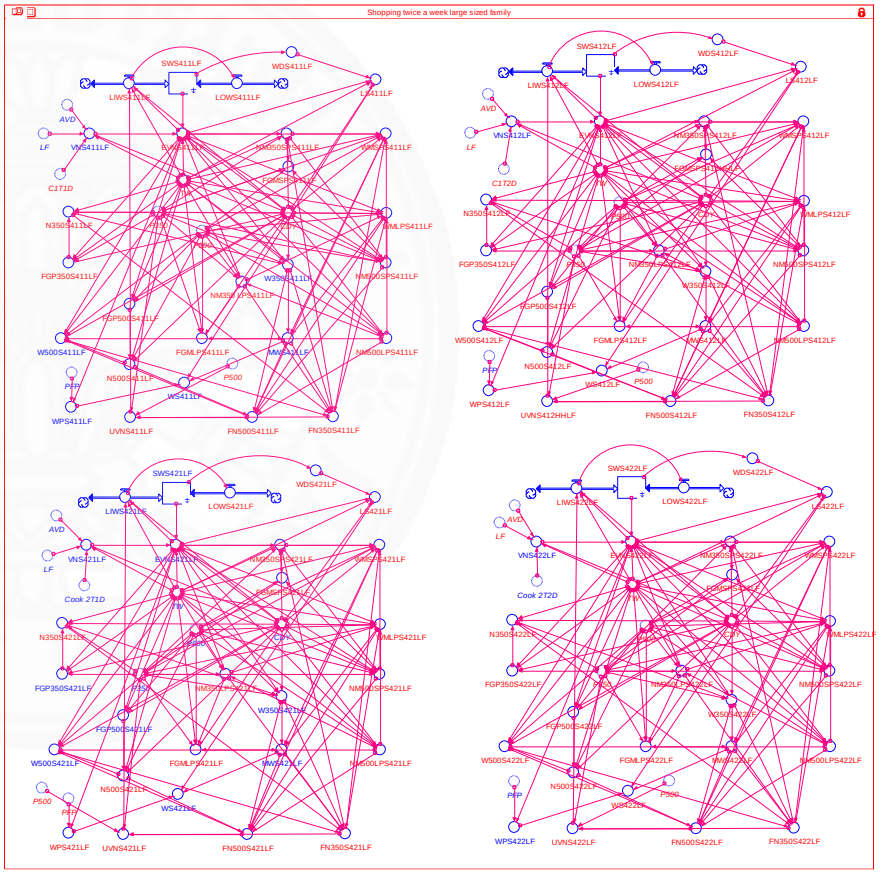
APPENDIX C
HOUSEHOLD SUB-MODEL



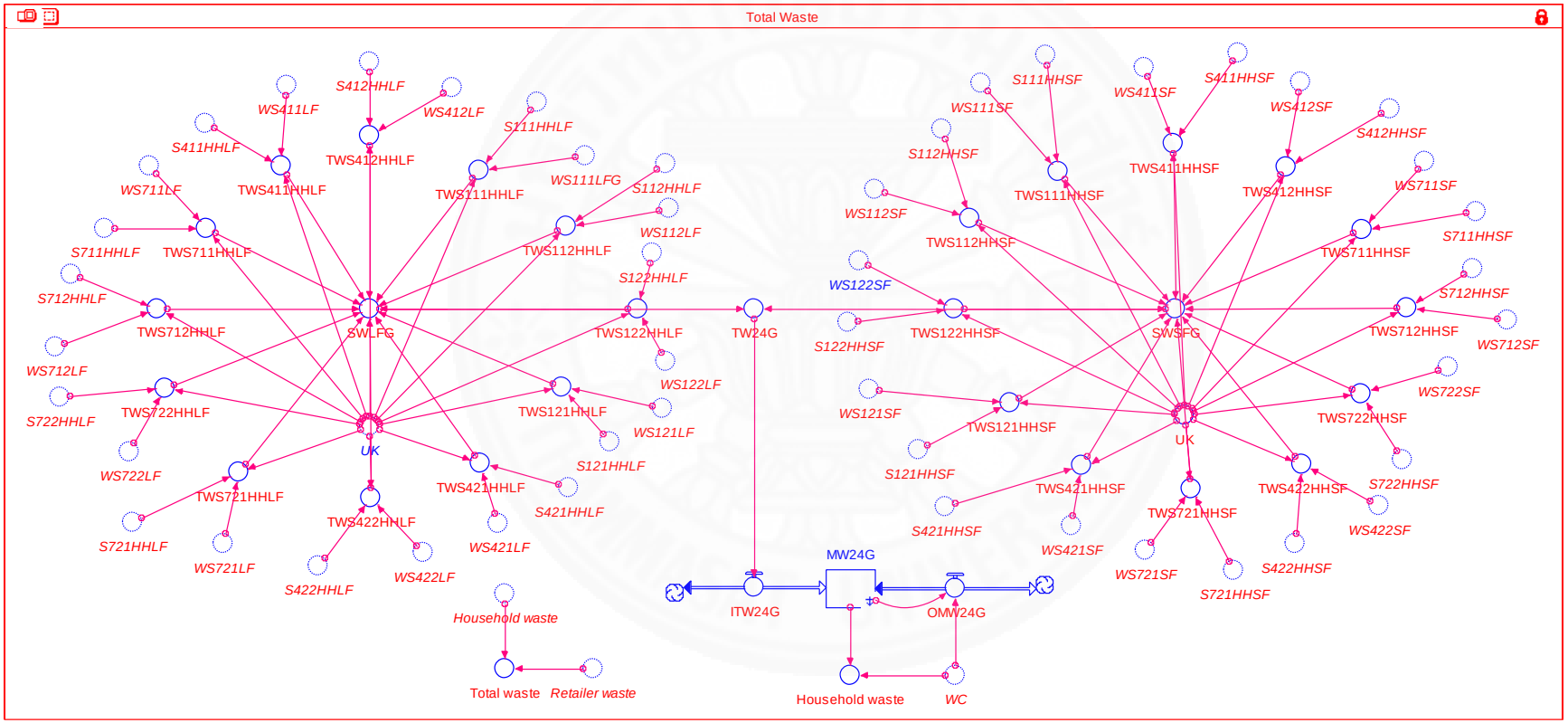


APPENDIX C
HOUSEHOLD SUB-MODEL

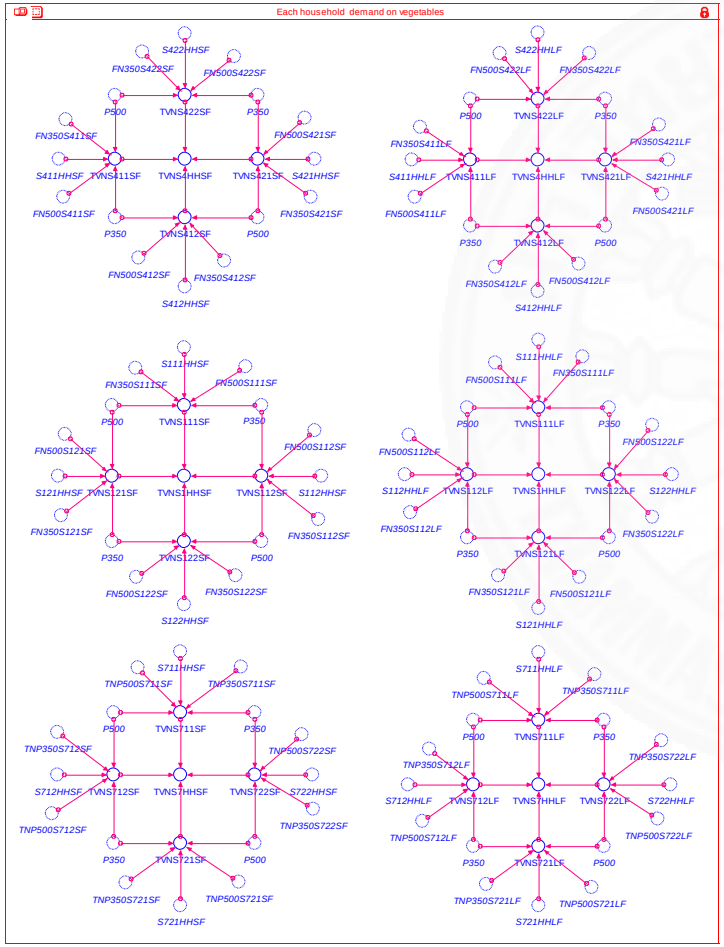


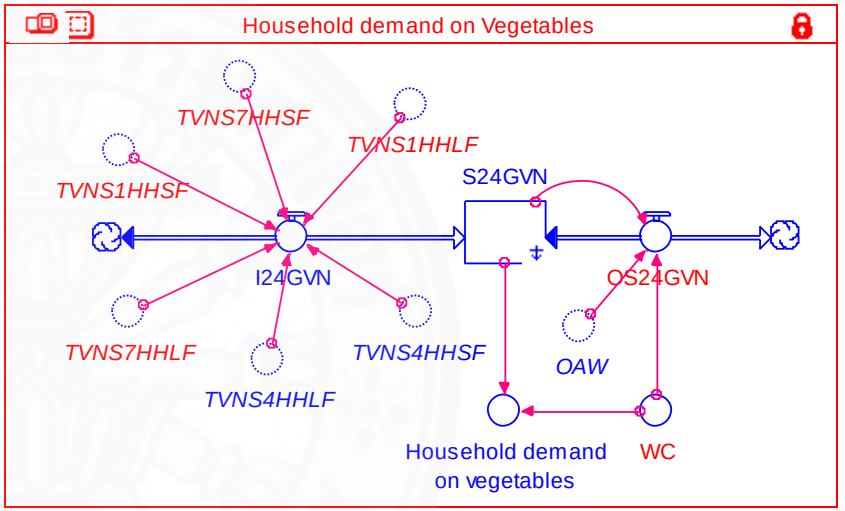


APPENDIX C
HOUSEHOLD SUB-MODEL



APPENDIX D
RETAILER SUB-MODEL





APPENDIX D
RETAILER SUB-MODEL

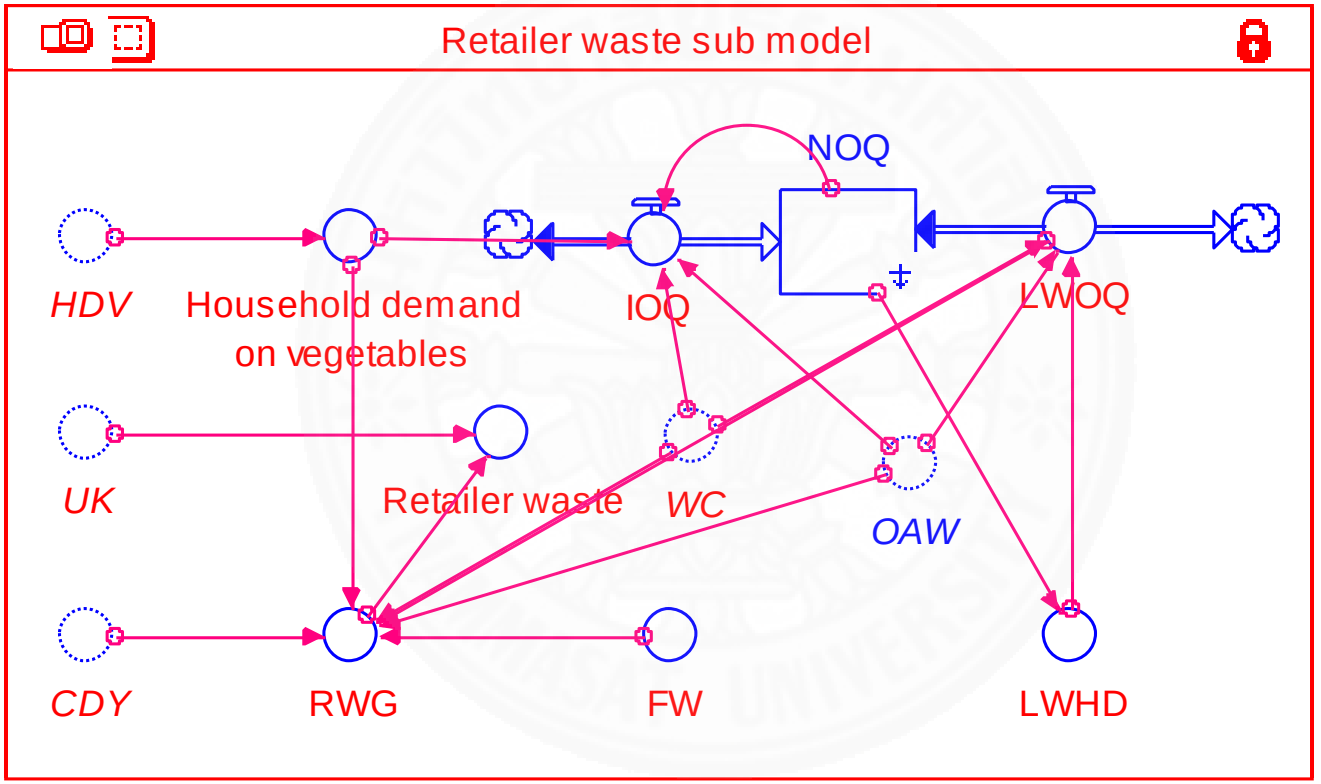
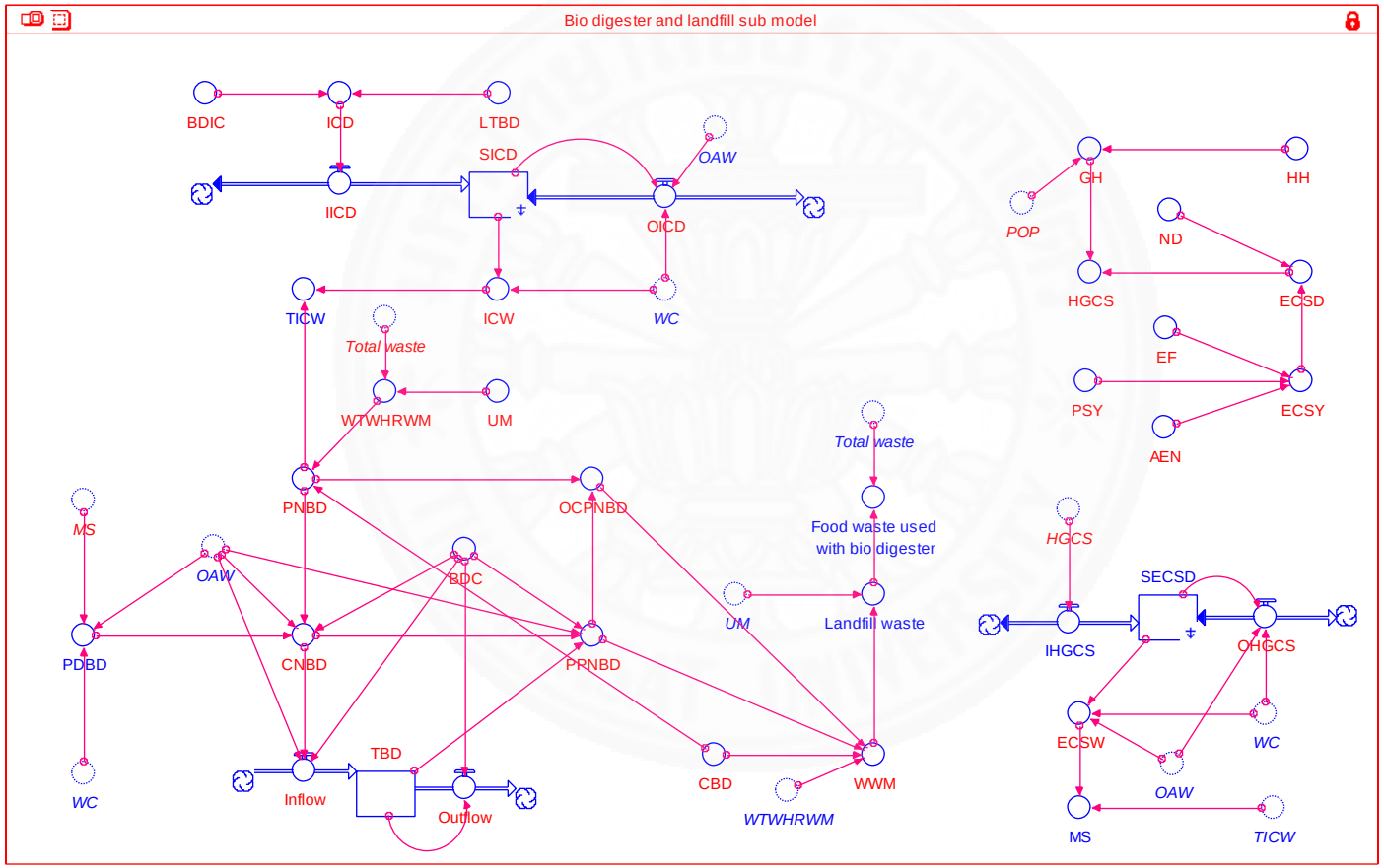


Figure 5.3b SD model of retailer waste sub-model

APPENDIX E
BIO-DIGESTER AND LANDFILL SUB-MODEL



APPENDIX F

SD EQUATIONS OF DYNAMICS MODELLING APPROACH OF FOOD WASTE

INFLOWS:

ITW24G = TW24G

INFLOWS:

IOQ = IF(WC/OAW) =INT(WC/OAW) THENMAX (Household_demand_on_vegetables_ w,NOQ) ELSE0

INFLOWS:

I24GVN = TVNS1HHLF+TVNS1HHSF+TVNS7HHLF+TVNS7HHSF+TVNS4HHLF+TVNS4HHSF

INFLOWS:

IHGCS = HGCS

INFLOWS:

IICD = ICD

INFLOWS:

ISTWEP = STWEP/1000

INFLOWS:

ITMW = TMW/1000

INFLOWS:

ITWP = TWP/1000

INFLOWS:

LIWS411LF = IF (CDY/TW) =INT(CDY/TW) THEN (UVNS411LF-EVNS411LF) ELSE 0

INFLOWS:

LIWS412LF =IF(CDY/TW) =INT(CDY/TW) THEN (UVNS412HHLF-EVNS412LF) ELSE 0

INFLOWS:

LIWS412SF = IF (CDY/TW) =INT(CDY/TW) THEN (UVNS412SF-EVNS412SF) ELSE 0

INFLOWS:

LIWS421LF = IF (CDY/TW) =INT(CDY/TW) THEN (UVNS421LF-EVNS421LF) ELSE 0

INFLOWS:

LIWS421SF = IF (CDY/TW) =INT(CDY/TW) THEN (UVNS421SF-EVNS421SF) ELSE 0

INFLOWS:

LIWS422LF = IF (CDY/TW) =INT(CDY/TW) THEN (UVNS422LF-EVNS422LF) ELSE 0

INFLOWS:

LIWS422SF = IF (CDY/TW) =INT(CDY/TW) THEN (UVNS422SF-EVNS422SF) ELSE 0

INFLOWS:

Inflow = IF BDC=OAW THEN CNBD ELSE 0

OUTFLOWS:

OMW24G = IF ((WC/8) =0) THEN MW24G ELSE 0

OUTFLOWS:

LWOQ = IF (WC/OAW)= 0 THEN LWHD ELSE 0

OUTFLOWS:

OS24GVN = IF ((WC/OAW) =0) THEN S24GVN ELSE 0

OUTFLOWS:

OHGCS = IF ((WC/OAW) =0) THEN SECSD ELSE 0

OUTFLOWS:

OICD = IF (WC/OAW=0) THEN SICD ELSE 0

OUTFLOWS:

OSSTWEP = IF ((WC/8) =0) THEN SSTWEP ELSE 0

OUTFLOWS:

OTMW = IF ((WC/8) =0) THEN STMW ELSE 0

OUTFLOWS:

OTWP = IF ((WC/8) =0) THEN STWP ELSE 0

OUTFLOWS:

LOWS411LF = DELAY (LIWS411LF, 4)

INFLOWS:

LIWS411SF = IF (CDY/TW) =INT(CDY/TW) THEN (UVNS411SF-EVNS411SF) ELSE 0

OUTFLOWS:

LOWS411SF = DELAY (LIWS411SF, 4)

OUTFLOWS:

LOWS412LF = DELAY (LIWS412LF, 4)

OUTFLOWS:

LOWS412SF = DELAY (LIWS412SF, 4)

OUTFLOWS:

LOWS421LF = DELAY (LIWS421LF, 4)

OUTFLOWS:

LOWS421SF = DELAY (LIWS421SF, 4)

OUTFLOWS:

LOWS422LF = DELAY (LIWS422LF, 4)

OUTFLOWS:

LOWS422SF = DELAY (LIWS422SF, 4)

OUTFLOWS:

Outflow = IF BDC=768 THEN TBD ELSE 0

AEN = 99.12

AVD = ROUND ((Morning_ glory_Cha_Tra_Kuen +Lok_Lak +Samlor_Machu_Kreung + Trey_Ch a_Cho Em)/4)

BDC = COUNTER (0,40000)

BDIC = 150

BPSF = 0.45

C1T1D = 1

C1T2D = 2

Capsicum = 85

Capsicum_Trey_Cha_Cho_Em = 43

Carrot = 30

CBD = 15

CDY = COUNTER(1,40000)

CNBD = IF PDBD = 1 THEN (IF BDC = OAW THEN PNBD ELSE 0) ELSE 0

Cook_2T1D = 2

Cook_2T2D = 4

Cucumber = 154

CWP = 0.64

ECSD = ECSY/ND

ECSW = IF((WC/OAW)=0) THEN SECSD ELSE 0

ECSY = AEN*PSY*EF

EF = 0.21

EVNS411LF = IF (CDY/TW) =INT(CDY/TW) THEN (MAX(0,(VNS411LF-SWS411LF))) ELSE 0

EVNS411SF = IF (CDY/TW) =INT(CDY/TW) THEN (MAX(0,(VNS411SF-SWS411SF))) ELSE 0

EVNS412LF = IF (CDY/TW) =INT(CDY/TW) THEN (MAX(0,(VNS412LF-SWS412LF))) ELSE 0

EVNS412SF = IF (CDY/TW) =INT(CDY/TW) THEN (MAX(0,(VNS412SF-SWS412SF))) ELSE 0

EVNS421LF = IF (CDY/TW) =INT(CDY/TW) THEN (MAX(0,(VNS421LF-SWS421LF))) ELSE 0

EVNS421SF = IF (CDY/TW) =INT(CDY/TW) THEN (MAX(0,(VNS421SF-SWS421SF))) ELSE 0

EVNS422LF = IF (CDY/TW) =INT(CDY/TW) THEN (MAX(0,(VNS422LF-SWS422LF))) ELSE 0

EVNS422SF = IF (CDY/TW) =INT(CDY/TW) THEN(MAX(0, (VNS422SF-SWS422SF))) ELSE 0

FG350S412SF = IF (CDY/TW) =INT(CDY/TW) THEN (IF (INT (EVNS412SF/P350) = (EVNS412SF/P350)) THEN EVNS412SF ELSE ((INT(EVNS412SF/ P350) +1)*P350)) ELSE 0

FGMLPS411LF=IF(CDY/TW)=INT(CDY/TW)THEN(NM350_LPS411LF*P350)+(NM500LPS411F *P500) ELSE 0

FGMLPS411SF=IF(CDY/TW)=INT(CDY/TW)THEN (NM350LPS411SF*P350) +(NM500LP S411SF *P500) ELSE 0

FGMLPS412LF=IF(CDY/TW)=INT(CDY/TW)THEN(NM350LPS412LF*P350)+ (NM500LP S412LF *P500) ELSE 0

FGMLPS412SF=IF(CDY/TW)=INT(CDY/TW)THEN(NM350LPS412SF*P350)+(NM500LPS412SF *P500) ELSE 0

FGMLPS421LF=IF(CDY/TW)=INT(CDY/TW)THEN(NM350LPS421LF*P350)+(NM500LPS421LF *P500) ELSE 0

FGMLPS421SF=IF(CDY/TW)=INT(CDY/TW)THEN(NM350LPS421SF*P350)+(NM500LPS421SF *P500) ELSE 0

FGMLPS422LF=IF(CDY/TW)=INT(CDY/TW)THEN(NM350LPS422LF*P350)+(NM500LPS422LF *P500) ELSE 0

FGMLPS422SF=IF(CDY/TW)=INT(CDY/TW)THEN(NM350LPS422SF*P350)+(NM500LPS422SF *P500) ELSE 0

FGMSPS411LF = (NM350SPS411LF*P350)+(NM500SPS411LF*P500)

FGMSPS411SF = (NM350SPS411SF*P350)+(NM500SPS411SF*P500)

FGMSPS412HHLF = (NM350SPS412LF*P350)+(NM500SPS412LF*P500)

FGMSPS412SF = (NM350SPS412SF*P350)+(NM500SPS412SF*P500)

FGMSPS421HHSF = (NM350SPS421SF*P350)+(NM500SPS421SF*P500)

FGMSPS421LF = (NM350SPS421LF*P350)+(NM500SPS421LF*P500)

FGMSPS422LF = (NM350SPS422LF*P350)+(NM500SPS422LF*P500)

FGMSPS422SF = (NM350SPS422SF*P350)+(NM500SPS422SF*P500)

FGP350S411LF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS411LF/P350)=(EVNS411LF/ P350))THEN EVNS411LF ELSE ((INT(EVNS411LF/P350)+1)*P350)) ELSE 0

FGP350S411SF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS411SF/P350)=(EVNS411SF/ P350))THEN EVNS411SF ELSE ((INT(EVNS411SF/P350)+1)*P350)) ELSE 0

FGP350S412LF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS412LF/P350)=(EVNS412LF/ P350))THEN EVNS412LF ELSE ((INT(EVNS412LF/P350)+1)*P350)) ELSE 0

FGP350S421LF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS421LF/P350)=(EVNS421LF/ P350))THEN EVNS421LF ELSE ((INT(EVNS421LF/P350)+1)*P350)) ELSE 0

FGP350S421SF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS421SF/P350)=(EVNS421SF/ P350))THEN EVNS421SF ELSE ((INT(EVNS421SF/P350)+1)*P350)) ELSE 0

FGP350S422LF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS422LF/P350)=(EVNS422LF/ P350))THEN EVNS422LF ELSE ((INT(EVNS422LF/P350)+1)*P350)) ELSE 0

FGP350S422SF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS422SF/P350)=(EVNS422SF/ P350))THEN EVNS422SF ELSE ((INT(EVNS422SF/P350)+1)*P350)) ELSE 0

FGP500S411LF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS411LF/P500)=(EVNS411LF/ P500))THEN EVNS411LF ELSE ((INT(EVNS411LF/P500)+1)*P500)) ELSE 0

FGP500S411SF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS411SF/P500)=(EVNS411SF/ P500))THEN EVNS411SF ELSE ((INT(EVNS411SF/P500)+1)*P500)) ELSE 0

FGP500S412LF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS412LF/P500)=(EVNS412LF/ P500))THEN EVNS412LF ELSE ((INT(EVNS412LF/P500)+1)*P500)) ELSE 0

FGP500S412SF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS412SF/P500)=(EVNS412SF/P500))THEN EVNS412SF ELSE ((INT(EVNS412SF/P500)+1)*P500)) ELSE 0

FGP500S421LF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS421LF/P500)=(EVNS421LF/P500))THEN EVNS421LF ELSE ((INT(EVNS421LF/P500)+1)*P500)) ELSE 0

FGP500S421SF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS421SF/P500)=(EVNS421SF/P500))THEN EVNS421SF ELSE ((INT(EVNS421SF/P500)+1)*P500)) ELSE 0

FGP500S422LF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS422LF/P500)=(EVNS422LF/P500))THEN EVNS422LF ELSE ((INT(EVNS422LF/P500)+1)*P500)) ELSE 0

FGP500S422SF=IF(CDY/TW)=INT(CDY/TW)THEN(IF(INT(EVNS422SF/P500)=(EVNS422SF/P500))THEN EVNS422SF ELSE ((INT(EVNS422SF/P500)+1)*P500)) ELSE 0

FN350S111LF = IF MWS111LF = W350S111LF THEN N350S111LF ELSE (IF MWS111LF = W500S111LF THEN 0 ELSE IF MWS111LF = WMLPS111LF THEN NM350LPS111LF ELSE WMSPS111LF = NM350SPS111LF)

FN350S111SF = IF MWS111SF = W350S111SF THEN N350S111SF ELSE (IF MWS111SF = W500S111SF THEN 0 ELSE IF MWS111SF = WMLPS111SF THEN NM350LPS111SF ELSE WMSPS111SF=NM350SPS111SF)

FN350S112LF = IF MWS112LF = W350S112LF THEN N350S112LF ELSE (IF MWS112LF = W500S112LF THEN 0 ELSE IF MWS112LF = WMLPS112LF THEN NM350LPS112LF ELSE WMSPS112LF=NM350SPS112LF)

FN350S112SF = IF MWS112SF = W350S112SF THEN N350S112SF ELSE (IF MWS112SF = W500S112SF THEN 0 ELSE IF MWS112SF = WMLPS112SF THEN NM350LPS112SF ELSE WMSPS112SF=NM350SPS112SF)

FN350S121LF = IF MWS121LF = W350S121LF THEN N350S121LF ELSE (IF MWS121LF = W500S121LF THEN 0 ELSE IF MWS121LF = WMLPS121LF THEN NM350LPS121HHLF ELSE WMSPS121LF=NM350SPS121LF)

FN350S121SF = IF MWS121SF = W350S121SF THEN N350S121SF ELSE (IF MWS121SF = W500S121SF THEN 0 ELSE IF MWS121SF = WMLPS121SF THEN NM350LPS121SF ELSE WMSPS121SF=NM350SPS121SF)

FN350S122LF = IF MWS122LF = W350S122LF THEN N350S122LF ELSE (IF MWS122LF = W500S122LF THEN 0 ELSE IF MWS122LF = WMLPS122LF THEN NM350LPS122LF ELSE WMSPS122LF=NM350SPS122LF)

FN350S122SF = IF MWS122SF = W350S122SF THEN N350S122SF ELSE(IF MWS122SF = W500S122SF THEN 0 ELSE IF MWS122SF = WMLPS122SF THEN NM350LPS122SF ELSE WMSPS122SF=NM350SPS122SF)

FN350S411LF = IF MWS411LF = W350S411LF THEN N350S411LF ELSE (IF MWS411LF = W500S411LF THEN 0 ELSE IF MWS411LF = WMLPS411LF THEN NM350_LPS411LF ELSE WMSPS411LF=NM350SPS411LF)

FN350S411SF = IF MWS411SF = W350S411SF THEN N350S411SF ELSE (IF MWS411SF

= W500S411SF THEN 0 ELSE IF MWS411SF = WMLPS411SF
THEN NM350LPS411SF ELSE WMSPS411SF=NM350SPS411SF)
FN350S412LF = IF MWS412LF = W350S412LF THEN N350S412LF ELSE (IF MWS412LF
= W500S412LF THEN 0 ELSE IF MWS412LF = WMLPS412LF
THEN NM350LPS412LF ELSE WMSPS412LF=NM350SPS412LF)
FN350S412SF = IF MWS412SF = W350S412SF THEN N350S412SF ELSE (IF MWS412SF
= W500S412SF THEN 0 ELSE IF MWS412SF = WMLPS412SF
THEN NM350LPS412SF ELSE WMSPS412SF=NM350SPS412SF)
FN350S421LF = IF MWS421LF = W350S421LF THEN N350S421LF ELSE(IF MWS421LF
= W500S421LF THEN 0 ELSE IF MWS421LF = WMLPS421LF
THEN NM350LPS421LF ELSE WMSPS421LF=NM350SPS421LF)
FN350S421SF = IF MWS421SF = W350S421SF THEN N350S421SF ELSE (IF MWS421SF
= W500S421SF THEN 0 ELSE IF MWS421SF = WMLPS421SF
THEN NM350LPS421SF ELSE WMSPS421SF=NM350SPS421SF)
FN350S422LF = IF MWS422LF = W350S422LF THEN N350S422LF ELSE (IF MWS422LF
= W500S422LF THEN 0 ELSE IF MWS422LF = WMLPS422LF
THEN NM350LPS422LF ELSE WMSPS422LF=NM350SPS422LF)
FN350S422SF = IF MWS422SF = W350S422SF THEN N350S422SF ELSE (IF MWS422SF
= W500S422SF THEN 0 ELSE IF MWS422SF = WMLPS422SF
THEN NM350LPS422SF ELSE WMSPS422SF=NM350SPS422SF)
FN350S711LF = IF MWS711LF = W350S711LF THEN N350S711LF ELSE (IF MWS711LF
= W500S711LF THEN 0 ELSE IF MWS711LF = WMLPS711LF
THEN NM350LPS711LF ELSE WMSPS711LF=NM350SPS711LF)
FN350S711SF = IF MWS711SF = W350S711SF THEN N350S711SF ELSE (IF MWS711SF
= W500S711SF THEN 0 ELSE IF MWS711SF = WMLPS711SF
THEN NM350LPS711SF ELSE WMSPS711SF=NM350SPS711SF)
FN350S712LF = IF MWS712LF = W350S712LF THEN N350S712LF ELSE (IF MWS712LF
= W500S712LF then 0 ELSE IF MWS712LF = WMLPS712LF
THEN NM350LPS712LF ELSE WMSPS712LF=NM350SPS712LF)
FN350S712SF = IF MWS712SF = W350S712SF THEN N350S712SF ELSE (IF MWS712SF
= W500S712SF THEN 0 ELSE IF MWS712SF = WMLPS712SF
THEN NM350LPS712SF ELSE WMSPS712SF=NM350SPS712SF)
FN350S721HHLF = IF MWS721LF = W350S721LF THEN N350S721LF ELSE (IF MWS721LF
= W500S721LF THEN 0 ELSE IF MWS721LF = WMLPS721LF
THEN NM350LPS721LF ELSE WMSPS721LF=NM350SPS721LF)
FN350S721SF = IF MWS721SF = W350S721SF THEN N350S721SF ELSE (IF MWS721SF
= W500S721SF THEN 0 ELSE IF MWS721SF = WMLPS721SF
THEN NM350LPS721SF ELSE WMSPS721SF=NM350SPS721SF)

FN350S722LF = IF MWS722LF = W350S722LF THEN N350S722LF ELSE (IF MWS722LF = W500S722LF THEN 0 ELSE IF MWS722LF = WMLPS722LF THEN NM350LPS722LF ELSE WMSPS722LF=NM350SPS722LF)

FN350S722SF = IF MWS722SF = W350S722SF THEN N350S722SF ELSE (IF MWS722SF = W500S722SF THEN 0 ELSE IF MWS722SF = WMLPS722SF THEN NM350LPS722SF ELSE WMMSPS722SF=NM350SPS722SF)

FN500S111LF = IF MWS111LF = W350S111LF THEN 0 ELSE (IF MWS111LF = W500S111LF THEN N500S111LF ELSE IF MWS111LF = WMLPS111LF THEN NM500_LPS111LF ELSE WMSPS111LF= NM500SPS111LF)

FN500S111SF = IF MWS111SF = W350S111SF THEN 0 ELSE (IF MWS111SF = W500S111SF THEN N500S111SF ELSE IF MWS111SF = WMLPS111SF THEN NM500LPS111SF ELSE WMSPS111SF= NM500SPS111SF)

FN500S112LF = IF MWS112LF = W350S112LF THEN 0 ELSE (F MWS112LF = W500S112LF THEN N500S112LF ELSE IF MWS112LF = WMLPS112LF THEN NM500LPS112LF ELSE WMSPS112LF= NM500SP112LF)

FN500S112SF = IF MWS112SF = W350S112SF THEN 0 ELSE (IF MWS112SF = W500S112SF THEN N500S112SF ELSE IF MWS112SF = WMLPS112SF THEN NM500LPS112SF ELSE WMSPS112SF= NM500SPS112SF)

FN500S121LF = IF MWS121LF = W350S121LF THEN 0 ELSE (IF MWS121LF = W500S121LF THEN N500S121LF ELSE IF MWS121LF = WMLPS121LF THEN NM500LPS121LF ELSE WMSPS121LF= NM500SPS121LF)

FN500S121SF = IF MWS121SF = W350S121SF THEN 0 ELSE (IF MWS121SF = W500S121SF THEN N500S121SF ELSE IF MWS121SF = WMLPS121SF THEN NM500LPS121SF ELSE WMSPS121SF= NM500SPS121SF)

FN500S122LF = IF MWS122LF = W350S122LF THEN 0 ELSE (IF MWS122LF = W500S122LF THEN N500S122LF ELSE IF MWS122LF = WMLPS122LF THEN NM500LPS122LF ELSE WMSPS122LF= NM500SPS122LF)

FN500S122SF = IF MWS122SF = W350S122SF THEN 0 ELSE (IF MWS122SF = W500S122SF THEN N500S122SF ELSE IF MWS122SF = WMLPS122SF THEN NM500LPS122SF ELSE WMSPS122SF= NM500SPS122SF)

FN500S411LF = IF MWS411LF = W350S411LF THEN 0 ELSE (IF MWS411LF = W500S411LF THEN N500S411LF ELSE IF MWS411LF = WMLPS411LF THEN NM500LPS411LF ELSE WMSPS411LF= NM500SPS411LF)

FN500S411SF = IF MWS411SF = W350S411SF THEN 0 ELSE (IF MWS411SF = W500S411SF THEN N500S411SF ELSE IF MWS411SF = WMLPS411SF THEN NM500LPS411SF ELSE WMSPS411SF= NM500SPS411SF)

FN500S412LF = IF MWS412LF = W350S412LF THEN 0 ELSE (IF MWS412LF = W500S412LF THEN N500S412LF ELSE IF MWS412LF = WMLPS412LF

THEN NM500LPS412LF ELSE WMSPS412LF= NM500SPS412LF)

FN500S412SF = IF MWS412SF = W350S412SF THEN 0 ELSE (IF MWS412SF = W500S412SF THEN N500S412SF ELSE IF MWS412SF = WMLPS412SF THEN NM500LPS412SF ELSE WMSPS412SF= NM500SPS412SF)

FN500S421LF = IF MWS421LF = W350S421LF THEN 0 ELSE (IF MWS421LF = W500S421LF THEN N500S421LF ELSE IF MWS421LF = WMLPS421LF THEN NM500LPS421LF else WMSPS421LF= NM500SPS421LF)

FN500S421SF = IF MWS421SF = W350S421SF THEN 0 ELSE (IF MWS421SF = W500S421SF THEN N500S421SF ELSE IF MWS421SF = WMLPS421SF THEN NM500LPS421SF ELSE WMSPS421SF= NM500SPS421SF)

FN500S422LF = IF MWS422LF = W350S422LF THEN 0 ELSE (IF MWS422LF = W500S422LF THEN N500S422LF ELSE IF MWS422LF = WMLPS422LF THEN NM500LPS422LF ELSE WMSPS422LF= NM500SPS422LF)

FN500S422SF = IF MWS422SF = W350S422SF THEN 0 ELSE (IF MWS422SF = W500S422SF THEN N500S422SF ELSE IF MWS422SF = WMLPS422SF THEN NM500LPS422SF ELSE WMSPS422SF= NM500SPS422SF)

FN500S711LF = IF MWS711LF = W350S711LF THEN 0 ELSE (IF MWS711LF = W500S711LF THEN N500S711LF ELSE IF MWS711LF = WMLPS711LF THEN NM500LPS711LF ELSE WMSPS711LF= NM500SP711LF)

FN500S711SF = IF MWS711SF = W350S711SF THEN 0 ELSE (IF MWS711SF = W500S711SF THEN N500S711SF ELSE IF MWS711SF = WMLPS711SF THEN NM500LPS711SF ELSE WMSPS711SF= NM500SPS711SF)

FN500S712LF = IF MWS712LF = W350S712LF THEN 0 ELSE (IF MWS712LF = W500S712LF THEN N500S712LF ELSE IF MWS712LF = WMLPS712LF THEN NM500LPS712LF ELSE WMSPS712LF= NM500SPS71LF)

FN500S712SF = IF MWS712SF = W350S712SF THEN 0 ELSE (IF MWS712SF = W500S712SF THEN N500S712SF ELSE IF MWS712SF = WMLPS712SF THEN NM500LPS712SF ELSE WMSPS712SF= NM500SPS712SF)

FN500S721SF = IF MWS721SF = W350S721SF THEN 0 ELSE (IF MWS721SF = W500S721SF THEN N500S721SF ELSE IF MWS721SF = WMLPS721SF THEN NM500_LPS721SF ELSE WMSPS721SF= NM500SPS721SF)

FN500S722LF = IF MWS722LF = W350S722LF THEN 0 ELSE (IF MWS722LF = W500S722LF THEN N500S722LF ELSE IF MWS722LF = WMLPS722LF THEN NM500LPS722LF ELSE WMSPS722LF= NM500SPS722LF)

FN500S722SF = IF MWS722SF = W350S722SF THEN 0 ELSE (IF MWS722SF = W500S722SF THEN N500S722SF ELSE IF MWS722SF = WMLPS722SF THEN NM500LPS722SF ELSE WMMSPS722SF= NM500SPS722SF)

FN500_S721LF = IF MWS721LF = W350S721LF THEN 0 ELSE (IF MWS721LF =

W500S721LF THEN N500S721LF ELSE IF MWS721LF = WMLPS721LF
THEN NM500LPS721LF ELSE WMSPS721LF= NM500SPS721LF)

Food_waste_used__with_bio_digester = Total_waste-Landfill_waste

FW = 9

GH = POP/HH

HGCS = GH*ECSD

HH = 90

HH_IN_RA_DY = 0.000074

Household_demand__on_vegetables = IF((WC/8)=0) THEN S24GVN ELSE 0

Household_demand__on_vegetables_w = Household_demand__on_vegetables

Household_waste = IF((WC/8)=0) THEN MW24G ELSE 0

ICD = BDIC/LTBD

ICW = IF(WC/8=0) THEN SICD ELSE 0

Landfill_waste = WWM/UM

Lettuce = 30

LF = 5

Lok_Lak = Cucumber+Lettuce+Tomato

LS411LF = IF (CDY/TW) =INT(CDY/TW) THEN (IF WDS411LF < (EVNS411LF*2)
THEN 0 ELSE (WDS411LF-(EVNS411LF*2))) ELSE 0

LS411SF = IF (CDY/TW) =INT(CDY/TW) THEN (IF WDS411SF < (EVNS411SF*2)
THEN 0 ELSE (WDS411SF-(EVNS411SF*2))) ELSE 0

LS412LF = IF (CDY/TW) =INT(CDY/TW) THEN (IF WDS412LF < (EVNS412LF*2)
THEN 0 ELSE (WDS412LF-(EVNS412LF*2))) ELSE 0

LS412SF = IF (CDY/TW) =INT(CDY/TW) THEN (IF WDS412SF < (EVNS412SF*2)
THEN 0 ELSE (WDS412SF-(EVNS412SF*2))) ELSE 0

LS421LF = IF (CDY/TW) =INT(CDY/TW) THEN (IF WDS421LF < (EVNS421LF*2)
THEN 0 ELSE (WDS421LF-(EVNS421LF*2))) ELSE 0

LS421SF = IF (CDY/TW) =INT(CDY/TW) THEN (IF WDS421SF < (EVNS421SF*2)
THEN 0 ELSE (WDS421SF-(EVNS421SF*2))) ELSE 0

LS422LF = IF (CDY/TW) =INT(CDY/TW) THEN (IF WDS422LF < (EVNS422LF*2)
THEN 0 ELSE (WDS422LF-(EVNS422LF*2))) ELSE 0

LS422SF = IF (CDY/TW) =INT(CDY/TW) THEN (IF WDS422SF < (EVNS422SF*2)
THEN 0 ELSE (WDS422SF-(EVNS422SF*2))) ELSE 0

LTBD = 1460

LWHD = HISTORY(NOQ,time-7)

Max_BPSF = 0.88

Max_PSF =IF(BPSF+(HH_IN_RA_DY*(CDY-
1)))<Max_BPSFTHEN(BPSF+(HH_IN_RA_DY*(CDY-1))) ELSE Max_BPSF

Morning_glory = 62.5

Morning_glory__Cha_Tra_Kuen = 150

MS = ECSW-TICW

MW24G(t) = MW24G(t - dt) + (ITW24G - OMW24G) * dt

MWS111LF = (MIN(W350S111LF,W500S111LF,WMLPS111LF,WMSPS111LF))

MWS111SF = (MIN(W350S111SF,W500S111SF,WMLPS111SF,WMSPS111SF))

MWS112LF = (MIN(W350S112LF,W500S112LF,WMLPS112LF,WMSPS112LF))

MWS112SF = (MIN(W350S112SF,W500S112SF,WMLPS112SF,WMSPS112SF))

MWS121LF = (MIN(W350S121LF,W500S121LF,WMLPS121LF,WMSPS121LF))

MWS121SF = (MIN(W350S121SF,W500S121SF,WMLPS121SF,WMSPS121SF))

MWS122LF = (MIN(W350S122LF,W500S122LF,WMLPS122LF,WMSPS122LF))

MWS122SF = (MIN(W350S122SF,W500S122SF,WMLPS122SF,WMSPS122SF))

MWS411LF = MIN(W350S411LF,W500S411LF,WMSPS411LF,WMLPS411LF)

MWS411SF = MIN(W350S411SF,W500S411SF,WMSPS411SF,WMLPS411SF)

MWS412LF = MIN(W350S412LF,W500S412LF,WMSPS412LF,WMLPS412LF)

MWS412SF = MIN(W350S412SF,W500S412SF,WMSPS412SF,WMLPS412SF)

MWS421LF = MIN(W350S421LF,W500S421LF,WMSPS421LF,WMLPS421LF)

MWS421SF = MIN(W350S421SF,W500S421SF,WMSPS421SF,WMLPS421SF)

MWS422LF = MIN(W350S422LF,W500S422LF,WMSPS422LF,WMLPS422LF)

MWS422SF = MIN(W350S422SF,W500S422SF,WMSPS422SF,WMLPS422SF)

MWS711LF = (MIN(W350S711LF,W500S711LF,WMLPS711LF,WMSPS711LF))

MWS711SF = (MIN(W350S711SF,W500S711SF,WMLPS711SF,WMSPS711SF))

MWS712LF = (MIN(W350S712LF,W500S712LF,WMLPS712LF,WMSPS712LF))+WPS712LF

MWS712SF = (MIN(W350S712SF,W500S712SF,WMLPS712SF,WMSPS712SF))

MWS721LF = (MIN(W350S721LF,W500S721LF,WMLPS721LF,WMSPS721LF))

MWS721SF = (MIN(W350S721SF,W500S721SF,WMLPS721SF,WMSPS721SF))

MWS722LF = (MIN(W350S722LF,W500S722LF,WMLPS722LF,WMSPS722LF))

MWS722SF = (MIN(W350S722SF,W500S722SF,WMLPS722SF,WMMSPS722SF))

NOQ(t) = NOQ(t - dt) + (IOQ - LWOQ) * dt

N350S111LF = IF(CDY/OAW)=INT(CDY/OAW)THEN ROUND((VNS111LF/P350)+0.5)ELSE 0

N350S111SF = IF(CDY/OAW) =INT(CDY/OAW)THENROUND((VNS111SF/P350)+0.5)ELSE 0

N350S112LF = IF(CDY/OAW)=INT(CDY/OAW)THEN ROUND((VNS112LF/P350)+0.5)ELSE 0

N350S112SF = IF(CDY/OAW) =INT(CDY/OAW)THENROUND((VNS112SF/P350)+0.5) LSE 0

N350S121LF = IF(CDY/OAW)=INT(CDY/OAW)THENROUND((VNS121LF/P350)+0.5) ELSE 0

N350S121SF = IF(CDY/OAW)=INT(CDY/OAW)THEN ROUND((VNS121SF/P350)+0.5)ELSE 0

N350S122LF =IF(CDY/OAW)=INT(CDY/OAW) THEN ROUND((VNS122LF/P350)+0.5) ELSE0

N350S122SF =IF(CDY/OAW)=INT(CDY/OAW) THEN ROUND((VNS122SF/P350)+0.5)ELSE0

N350S411LF = IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP350S411LF/P350) ELSE 0

N350S411SF = IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP350S411SF/P350) ELSE 0
N350S412LF = IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP350S412LF/P350) ELSE 0
N350S412SF = IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FG350S412SF/P350) ELSE 0
N350S421LF = IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP350S421LF/P350) ELSE 0
N350S421SF = IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP350S421SF/P350) ELSE 0
N350S422LF = IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP350S422LF/P350) ELSE 0
N350S422SF = IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP350S422SF/P350) ELSE 0
N350S711LF = ROUND((VNS711LF/P350)+0.5)
N350S711SF = ROUND((VNS711SF/P350)+0.5)
N350S712LF = ROUND((VNS712LF/P350)+0.5)
N350S712SF = ROUND((VNS712SF/P350)+0.5)
N350S721LF = ROUND((VNS721LF/P350)+0.5)
N350S721SF = ROUND((VNS721SF/P350)+0.5)
N350S722LF = ROUND((VNS722LF/P350)+0.5)
N350S722SF = ROUND((VNS722SF/P350)+0.5)
N500S111LF = IF(CDY/OAW) =INT(CDY/OAW)THENROUND((VNS111LF/P500)+0.5)ELSE 0
N500S111SF =IF(CDY/OAW) =INT(CDY/OAW)THEN ROUND((VNS111SF/P500)+0.5)ELSE0
N500S112LF =IF(CDY/OAW)=INT(CDY/OAW)THENROUND((VNS112LF/P500)+0.5) ELSE 0
N500S112SF = IF(CDY/OAW)=INT(CDY/OAW)THENROUND((VNS112SF/P500)+0.5)ELSE 0
N500S121LF = IF(CDY/OAW)=INT(CDY/OAW)THENROUND((VNS121LF/P500)+0.5)ELSE 0
N500S121SF = IF(CDY/OAW) =INT(CDY/OAW)THENROUND((VNS121SF/P500)+0.5)ELSE0
N500S122LF=IF (CDY/OAW)=INT(CDY/OAW)THEN ROUND((VNS122LF/P500)+0.5)ELSE0
N500S122SF= IF(CDY/OAW)=INT(CDY/OAW)THENROUND((VNS122SF/P500)+0.5)ELSE 0
N500S411LF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP500S411LF/P500) ELSE 0
N500S411SF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP500S411SF/P500) ELSE 0
N500S412LF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP500S412LF/P500) ELSE 0
N500S412SF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP500S412SF/P500) ELSE 0
N500S421LF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP500S421LF/P500) ELSE 0
N500S421SF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP500S421SF/P500) ELSE 0
N500S422LF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP500S422LF/P500) ELSE 0
N500S422SF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND(FGP500S422SF/P500) ELSE 0
N500S711LF= ROUND((VNS711LF/P500)+0.5)
N500S711SF= ROUND((VNS711SF/P500)+0.5)
N500S712LF= ROUND((VNS712LF/P500)+0.5)
N500S712SF= ROUND((VNS712SF/P500)+0.5)
N500S721LF= ROUND((VNS721LF/P500)+0.5)
N500S721SF= ROUND((VNS721SF/P500)+0.5)
N500S722LF= ROUND((VNS722LF/P500)+0.5)

N500S722SF = ROUND((VNS722SF/P500)+0.5)

ND = 365

NEP350S711LF = ROUND(IF PCD = 7 THEN PRO*FN350S711LF ELSE (IF PCD = 8 THEN PRO*FN350S711LF ELSE 0))

NEP350S711SF = ROUND(IF PCD = 7 THEN PRO*FN350S711SF ELSE (IF PCD = 8 THEN PRO*FN350S711SF ELSE 0))

NEP350S712LF = ROUND(IF PCD = 7 THEN PRO*FN350S712LF ELSE (IF PCD = 8 THEN PRO*FN350S712LF ELSE 0))

NEP350S712SF = ROUND(IF PCD = 7 THEN PRO*FN350S712SF ELSE (IF PCD = 8 THEN PRO*FN350S712SF ELSE 0))

NEP350S721LF = ROUND (IF PCD = 7 THEN PRO*FN350S721HHLF ELSE (IF PCD = 8 THEN PRO*FN350S721HHLF ELSE 0))

NEP350S721SF = ROUND(IF PCD = 7 THEN PRO*FN350S721SF ELSE (IF PCD = 8 THEN PRO*FN350S721SF ELSE 0))

NEP350S722LF = ROUND(IF PCD = 7 THEN PRO*FN350S722LF ELSE (IF PCD = 8 THEN PRO*FN350S722LF ELSE 0))

NEP350S722SF = ROUND(IF PCD = 7 THEN PRO*FN350S722SF ELSE (IF PCD = 8 THEN PRO*FN350S722SF ELSE 0))

NEP500S711LF = ROUND(IF PCD = 7 THEN PRO*FN500S711LF ELSE (IF PCD = 8 THEN PRO*FN500S711LF ELSE 0))

NEP500S711SF = ROUND(IF PCD = 7 THEN PRO*FN500S711SF ELSE (IF PCD = 8 THEN PRO*FN500S711SF ELSE 0))

NEP500S712LF = ROUND(IF PCD = 7 THEN PRO*FN500S712LF ELSE (IF PCD = 8 THEN PRO*FN500S712LF ELSE 0))

NEP500S712SF = ROUND(IF PCD = 7 THEN PRO*FN500S712SF ELSE (if PCD = 8 THEN PRO*FN500S712SF ELSE 0))

NEP500S721LF = ROUND(IF PCD = 7 THEN PRO*FN500_S721LF ELSE (IF PCD = 8 THEN PRO*FN500_S721LF ELSE 0))

NEP500S721SF = ROUND(IF PCD = 7 THEN PRO*FN500S721SF ELSE (IF PCD = 8 THEN PRO*FN500S721SF ELSE 0))

NEP500S722LF = ROUND(IF PCD = 7 THEN PRO*FN500S722LF ELSE (IF PCD = 8 THEN PRO*FN500S722LF ELSE 0))

NEP500S722SF = ROUND(IF PCD = 7 THEN PRO*FN500S722SF ELSE (IF PCD = 8 THEN PRO*FN500S722SF ELSE 0))

NM350LPS111LF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND (((VNS111LF-(NM500_LPS111LF*P500))/P350)+0.5)) ELSE 0

NM350LPS111SF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND (((VNS111SF-(NM500LPS111SF*P500))/P350)+0.5)) ELSE 0

NM350LPS112LF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
(((VNS112LF-(NM500LPS112LF*P500))/P350)+0.5)) ELSE 0
NM350LPS112SF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
(((VNS112SF-(NM500LPS112SF*P500))/P350)+0.5)) ELSE 0
NM350LPS121HHLF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
(((VNS121LF-(NM500LPS121LF*P500))/P350)+0.5)) ELSE 0
NM350LPS121SF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
(((VNS121SF-(NM500LPS121SF*P500))/P350)+0.5)) ELSE 0
NM350LPS122LF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
(((VNS122LF-(NM500LPS122LF*P500))/P350)+0.5)) ELSE 0
NM350LPS122SF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
(((VNS122SF-(NM500LPS122SF*P500))/P350)+0.5)) ELSE 0
NM350LPS411SF= IF (TW/TW) =INT(TW/TW) THEN (ROUND
(((EVNS411SF-(NM500LPS411SF*P500))/P350)+0.5)) ELSE 0
NM350LPS412LF= IF (TW/TW) =INT(TW/TW) THEN (ROUND
(((EVNS412LF-(NM500LPS412LF*P500))/P350)+0.5)) ELSE 0
NM350LPS412SF= IF (TW/TW) =INT(TW/TW) THEN (ROUND
(((EVNS412SF-(NM500LPS412SF*P500))/P350)+0.5)) ELSE 0
NM350LPS421LF= IF (TW/TW) =INT(TW/TW) THEN (ROUND
(((EVNS421LF-(NM500LPS421LF*P500))/P350)+0.5)) ELSE 0
NM350LPS421SF= IF (TW/TW) =INT(TW/TW) THEN (ROUND
(((EVNS421SF-(NM500LPS421SF*P500))/P350)+0.5)) ELSE 0
NM350LPS422LF= IF (TW/TW) =INT(TW/TW) THEN (ROUND
(((EVNS422LF-(NM500LPS422LF*P500))/P350)+0.5)) ELSE 0
NM350LPS422SF= IF (TW/TW) =INT(TW/TW) THEN (ROUND
(((EVNS422SF-(NM500LPS422SF*P500))/P350)+0.5)) ELSE 0
NM350LPS711LF = ROUND(((VNS711LF-(NM500LPS711LF*P500))/P350)+0.5)
NM350LPS711SF = ROUND(((VNS711SF-(NM500LPS711SF*P500))/P350)+0.5)
NM350LPS712LF = ROUND(((VNS712LF-(NM500LPS712LF*P500))/P350)+0.5)
NM350LPS712SF = ROUND(((VNS712SF-(NM500LPS712SF*P500))/P350)+0.5)
NM350LPS721LF = ROUND(((VNS721LF-(NM500LPS721LF*P500))/P350)+0.5)
NM350LPS721SF = ROUND(((VNS721SF-(NM500_LPS721SF*P500))/P350)+0.5)
NM350LPS722LF = ROUND(((VNS722LF-(NM500LPS722LF*P500))/P350)+0.5)
NM350LPS722SF = ROUND(((VNS722SF-(NM500LPS722SF*P500))/P350)+0.5)
NM350SPS111LF = IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
((VNS111LF/P350)-0.5)) ELSE 0
NM350SPS111SF = IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
((VNS111SF/P350)-0.5)) ELSE 0

NM350SPS112LF = IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
((VNS112LF/P350)-0.5)) ELSE 0
NM350SPS112SF = IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
((VNS112SF/P350)-0.5)) ELSE 0
NM350SPS121LF = IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
((VNS121LF/P350)-0.5)) ELSE 0
NM350SPS121SF = IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
((VNS121SF/P350)-0.5)) ELSE 0
NM350SPS122LF = IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
((VNS122LF/P350)-0.5)) ELSE 0
NM350SPS122SF = IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND
((VNS122SF/P350)-0.5)) ELSE 0
NM350SPS411LF = IF (CDY/TW)=INT(CDY/TW)THEN(ROUND((EVNS411LF/P350)-0.5))
ELSE 0
NM350SPS411SF = IF (CDY/TW) =INT(CDY/TW)THEN(ROUND((EVNS411SF/P350)-0.5))
ELSE 0
NM350SPS412LF = IF(CDY/TW)=INT(CDY/TW) THEN (ROUND((EVNS412LF/P350)-0.5))
ELSE0
NM350SPS412SF = IF(CDY/TW) =INT(CDY/TW)THEN(ROUND((EVNS412SF/P350)-0.5))
ELSE 0
NM350SPS421LF = IF (CDY/TW)=INT(CDY/TW)THEN(ROUND((EVNS421LF/P350)-0.5))
ELSE 0
NM350SPS421SF = IF (CDY/TW) =INT(CDY/TW)THEN(ROUND((EVNS421SF/P350)-0.5))
ELSE 0
NM350SPS422LF = IF (CDY/TW =INT(CDY/TW)THEN(ROUND((EVNS422LF/P350)-0.5))
ELSE 0
NM350SPS422SF = IF (CDY/TW) =INT(CDY/TW)THEN(ROUND((EVNS422SF/P350)-0.5))
ELSE 0
NM350SPS711LF = ROUND((VNS711LF/P350)-0.5)
NM350SPS711SF = ROUND((VNS711SF/P350)-0.5)
NM350SPS712LF = ROUND((VNS712LF/P350)-0.5)
NM350SPS712SF = ROUND((VNS712SF/P350)-0.5)
NM350SPS721LF = ROUND((VNS721LF/P350)-0.5)
NM350SPS721SF = ROUND((VNS721SF/P350)-0.5)
NM350SPS722LF = ROUND((VNS722LF/P350)-0.5)
NM350SPS722SF = ROUND((VNS722SF/P350)-0.5)
NM350_LPS411LF= IF (TW/TW) =INT(TW/TW) THEN (ROUND
(((EVNS411LF-(NM500LPS411LF*P500))/P350)+0.5)) ELSE 0

NM500LPS111SF= IF (CDY/OAW) =INT(CDY/OAW) THEN ROUND
((VNS111SF/P500)-0.5) ELSE 0
NM500LPS112LF= IF (CDY/OAW) =INT(CDY/OAW) THEN ROUND
((VNS112LF/P500)-0.5) ELSE 0
NM500LPS112SF= IF (CDY/OAW) =INT(CDY/OAW) THEN ROUND
((VNS112SF/P500)-0.5) ELSE 0
NM500LPS121LF= IF (CDY/OAW) =INT(CDY/OAW) THEN ROUND
((VNS121LF/P500)-0.5) ELSE 0
NM500LPS121SF= IF (CDY/OAW) =INT(CDY/OAW) THEN ROUND
((VNS121SF/P500)-0.5) ELSE 0
NM500LPS122LF= IF (CDY/OAW) =INT(CDY/OAW) THEN ROUND
((VNS122LF/P500)-0.5) ELSE 0
NM500LPS122SF= IF (CDY/OAW) =INT(CDY/OAW) THEN ROUND
((VNS122SF/P500)-0.5) ELSE 0
NM500LPS411LF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND((EVNS411LF/P500)-0.5)
ELSE 0
NM500LPS411SF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND((EVNS411SF/P500)-0.5)
ELSE 0
NM500LPS412LF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND((EVNS412LF/P500)-0.5)
ELSE 0
NM500LPS412SF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND((EVNS412SF/P500)-0.5)
ELSE 0
NM500LPS421LF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND((EVNS421LF/P500)-0.5)
ELSE 0
NM500LPS421SF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND((EVNS421SF/P500)-0.5)
ELSE 0
NM500LPS422LF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND((EVNS422LF/P500)-0.5)
ELSE 0
NM500LPS422SF= IF (CDY/TW) =INT(CDY/TW) THEN ROUND((EVNS422SF/P500)-0.5)
ELSE 0
NM500LPS711LF = ROUND((VNS711LF/P500)-0.5)
NM500LPS711SF = ROUND((VNS711SF/P500)-0.5)
NM500LPS712LF = ROUND((VNS712LF/P500)-0.5)
NM500LPS712SF = ROUND((VNS712SF/P500)-0.5)
NM500LPS721LF = ROUND((VNS721LF/P500)-0.5)
NM500LPS722LF = ROUND((VNS722LF/P500)-0.5)
NM500LPS722SF = ROUND((VNS722SF/P500)-0.5)
NM500SP112LF = IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND

(((VNS112LF-(NM350SPS112LF*P350))/P500)+0.5)) ELSE 0

NM500SP711LF = ROUND(((VNS711LF-(NM350SPS711LF*P350))/P500)+0.5)

NM500SPS111LF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND

(((VNS111LF-(NM350SPS111LF*P350))/P500)+0.5)) ELSE 0

NM500SPS111SF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND

(((VNS111SF-(NM350SPS111SF*P350))/P500)+0.5)) ELSE 0

NM500SPS112SF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND

(((VNS112SF-(NM350SPS112SF*P350))/P500)+0.5)) ELSE 0

NM500SPS121LF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND

(((VNS121LF-(NM350SPS121LF*P350))/P500)+0.5)) ELSE 0

NM500SPS121SF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND

(((VNS121SF-(NM350SPS121SF*P350))/P500)+0.5)) ELSE 0

NM500SPS122LF= IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND

(((VNS122LF-(NM350SPS122LF*P350))/P500)+0.5)) ELSE 0

NM500SPS122SF=IF (CDY/OAW) =INT(CDY/OAW) THEN (ROUND

(((VNS122SF-(NM350SPS122SF*P350))/P500)+0.5)) ELSE 0

NM500SPS411LF= IF (CDY/TW) =INT(CDY/TW) THEN (ROUND

(((EVNS411LF-(NM350SPS411LF*P350))/P500)+0.5)) ELSE 0

NM500SPS411SF= IF (CDY/TW) =INT(CDY/TW) THEN (ROUND

(((EVNS411SF-(NM350SPS411SF*P350))/P500)+0.5)) ELSE 0

NM500SPS412LF= IF (CDY/TW) =INT(CDY/TW) THEN (ROUND

(((EVNS412LF-(NM350SPS412LF*P350))/P500)+0.5)) ELSE 0

NM500SPS412SF= IF (CDY/TW) =INT(CDY/TW) THEN (ROUND

(((EVNS412SF-(NM350SPS412SF*P350))/P500)+0.5)) ELSE 0

NM500SPS421LF = IF (CDY/TW) =INT(CDY/TW) THEN (ROUND

(((EVNS421LF-(NM350SPS421LF*P350))/P500)+0.5)) ELSE 0

NM500SPS421SF= IF (CDY/TW) =INT(CDY/TW) THEN (ROUND

(((EVNS421SF-(NM350SPS421SF*P350))/P500)+0.5)) ELSE 0

NM500SPS422LF= IF (CDY/TW) =INT(CDY/TW) THEN (ROUND

(((EVNS422LF-(NM350SPS422LF*P350))/P500)+0.5)) ELSE 0

NM500SPS422SF= IF (CDY/TW) =INT(CDY/TW) THEN (ROUND

(((EVNS422SF-(NM350SPS422SF*P350))/P500)+0.5)) ELSE 0

NM500SPS711SF = ROUND(((VNS711SF-(NM350SPS711SF*P350))/P500)+0.5)

NM500SPS712SF = ROUND(((VNS712SF-(NM350SPS712SF*P350))/P500)+0.5)

NM500SPS71LF = ROUND(((VNS712LF-(NM350SPS712LF*P350))/P500)+0.5)

NM500SPS721LF = ROUND(((VNS721LF-(NM350SPS721LF*P350))/P500)+0.5)

NM500SPS721SF = ROUND(((VNS721SF-(NM350SPS721SF*P350))/P500)+0.5)

NM500SPS722LF = ROUND(((VNS722LF-(NM350SPS722LF*P350))/P500)+0.5)

NM500SPS722SF = ROUND(((VNS722SF-(NM350SPS722SF*P350))/P500)+0.5)

NM500_LPS111LF= IF (CDY/OAW) =INT(CDY/OAW) THEN ROUND
((VNS111LF/P500)-0.5) ELSE 0

NM500_LPS721SF = ROUND((VNS721SF/P500)-0.5)

OAW = 8

OCPNBD = MAX(0,PNBD-PPNBD)

P350 = 350

P500 = 500

PCD = COUNTER(1,9)

PDBD = IF (WC/OAW)=0 THEN (IF MS >= 0 THEN 1 ELSE 0) ELSE 0

PFP = 0.11

PNBD = ROUND(WTWHRWM/CBD)

POP = ROUND(308554*PO_IN_RA^(CDY-1))

PO_IN_RA = 1.00004

PPNBD = IF (BDC/OAW) = INT(BDC/OAW) THEN (ROUND(IF CNBD=0
THEN TBD ELSE CNBD)) ELSE 0

PRO = 1/4

PS112HHLF = 0.60

PS112HHSF = 0.75

PS11HHLF = 0.53

PS122HHLF = 0.67

PS122HHSF = 0.83

PS12HHSF = 0.60

PS1HHLF = 0.29

PS411HHLF = 0.60

PS412HHSF = 0.80

PS422HHLF = 0.95

PS422HHSF = 0.58

PS42HHLF = 0.69

PS42HHSF = 0.84

PS4HHLF = 0.48

PS4HHSF = 0.58

PS712HHLF = 0.67

PS712HHSF = 1

PS722HHLF = 0.89

PS722HHSF = 0.71

PS72HHLF = 0.60

PS72HHSF = 0.58

PS7HHSF = 0.23
PSSF = 0.45
PSY = 0.57
Retailer_waste = MAX(0,(RWG/UK))
RWG = IF CDY=FW THEN 0 ELSE (IF (WC/OAW) = INT(WC/OAW) THEN (LWOQ-Household_demand__on_vegetables_w) ELSE 0)
S111HHLF = ROUND(S11HHLF-S112HHLF)
S111HHSF = ROUND(S11HHSF-S112HHSF)
S112HHLF = ROUND(PS112HHLF*S11HHLF)
S112HHSF = ROUND(PS112HHSF*S11HHSF)
S11HHLF = ROUND(PS11HHLF*S1HHLF)
S11HHSF = ROUND(S1HHSF-S12HHSF)
S121HHLF = ROUND(S12HHLF-S122HHLF)
S121HHSF = ROUND(S12HHSF-S122HHSF)
S122HHLF = ROUND(PS122HHLF*S12HHLF)
S122HHSF = ROUND(PS122HHSF*S12HHSF)
S12HHLF = ROUND(S1HHLF-S11HHLF)
S12HHSF = ROUND(PS12HHSF*S1HHSF)
S1HHLF = ROUND(TNLF*PS1HHLF)
S1HHSF = TNSF-S7HHSF-S4HHSF
S411HHLF = ROUND(PS411HHLF*S41HHLF)
S411HHSF = ROUND(S41HHSF-S412HHSF)
S412HHLF = ROUND(S41HHLF-S411HHLF)
S412HHSF = ROUND(PS412HHSF*S41HHSF)
S41HHLF = ROUND(S4HHLF-S42HHLF)
S41HHSF = ROUND(S4HHSF-S42HHSF)
S421HHLF = ROUND(S42HHLF-S422HHLF)
S421HHSF = ROUND(S42HHSF-S422HHSF)
S422HHLF = ROUND(PS422HHLF*S42HHLF)
S422HHSF = ROUND(PS422HHSF*S42HHSF)
S42HHLF = ROUND(PS42HHLF*S4HHLF)
S42HHSF = ROUND(PS42HHSF*S4HHSF)
S4HHLF = ROUND(TNLF*PS4HHLF)
S4HHSF = ROUND(TNSF*PS4HHSF)
S711HHLF = S71HHLF-S712HHLF
S711HHSF = S71HHSF-S712HHSF
S712HHLF = ROUND(S71HHLF*PS712HHLF)
S712HHSF = ROUND(S71HHSF*PS712HHSF)

S71HHLF = ROUND(S7HHLF-S72HHLF)
S71HHSF = ROUND(S7HHSF-S72HHSF)
S721HHLF = ROUND(S72HHLF-S722HHLF)
S721HHSF = ROUND(S72HHSF-S722HHSF)
S722HHLF = ROUND(S72HHLF*PS722HHLF)
S722HHSF = ROUND(S72HHSF*PS722HHSF)
S72HHLF = ROUND(PS72HHLF*S7HHLF)
S72HHSF = ROUND(PS72HHSF*S7HHSF)
S7HHLF = TNLF-S1HHLF-S4HHLF
S7HHSF = ROUND(TNSF*PS7HHSF)
Samlor_Machu_Kreung = Capsicum+Morning_glory
SF = 2
SPWEPS711LF = WPEP350S711LF+WPEP500S711LF
SPWEPSS711SF = WPEP350S711SF+WPEP500S711SF
SPWEPSS712LF = WPEP350S712LF+WPEP500S712LF
SPWEPSS712SF = WPEP350S712SF+WPEP500S712SF
SPWEPSS721LF = WPEP350S721LF+WPEP500S721LF
SPWEPSS721SF = WPEP350S721SF+WPEP500S721SF
SPWEPSS722LF = WPEP350S722LF+WPEP500S722LF
SPWEPSS722SF = WPEP350S722HHSF+WPEP500S722HHSF
SSF = ROUND(PSSF*POP)
STWEP =(S711HHLF*TWEPS711LF)+(S711HHSF*TWEPS711SF)+(S712HHLF* TWEPS712LF) + (S712HHSF *TWEPS712SF) +(S721HHLF *TWEPS721LF)+(S721HHSF*TWEPS721SF)+(S722HHLF*TWEPS722LF) +(S722HHSF* TWEPS722SF)
STWEPWKG = IF((WC/8)=0) THEN SSTWEP ELSE 0
SWEPS711LF = WNEP350S711LF+WNEP500S711LF
SWEPS711SF = WNEP350S711SF+WNEP500S711SF
SWEPS712LF = WNEP350S712LF+WNEP500S712LF
SWEPS712SF = WNEP350S712SF+WNEP500S712SF
SWEPS721LF = WMEP350S721LF+WNEP500S721LF
SWEPS721SF = WNEP350S721SF+WNEP500S721SF
SWEPS722LF = WNEP350S722LF+WNEP500S722LF
SWEPS722SF = WNEP350S722HHSF+WNEP500S722HHSF
SWLFG =ROUND(TWS111HHLF+TWS112HHLF+TWS121HHLF+TWS122HHLF+ TWS411HHLF+ TWS412HHLF+TWS421HHLF+TWS422HHLF+ TWS711HHLF+ TWS712HHLF+TWS721HHLF+TWS722HHLF)

SWSFG =ROUND(TWS111HHSF+TWS112HHSF+TWS121HHSF+TWS122HHSF+
TWS411HHSF+TWS412HHSF+TWS421HHSF+TWS422HHSF+TWS711HHSF
+TWS712HHSF+TWS721HHSF+TWS722HHSF)

TICW = PNBD*ICW

TMW =(MWS111LF*S111HHLF)+(MWS111SF*S111HHSF)+(MWS112LF*
S112HHLF)+(MWS112SF*S112HHSF)+(MWS121LF*S121HHLF)+
(MWS121SF*S121HHSF)+(MWS122LF*S122HHLF)+(MWS122SF*
S122HHSF)+(MWS411LF*S411HHLF)+(MWS411SF*S411HHSF)+
(MWS412LF*S412HHLF)+(MWS412SF*S412HHSF)+(MWS421LF*
S421HHLF)+(MWS421SF*S421HHSF)+(MWS422LF*S422HHLF)+
(MWS422SF*S422HHSF)+(MWS711LF*S711HHLF)+(MWS711SF*
S711HHSF)+(MWS712LF*S712HHLF)+(MWS712SF*S712HHSF)+
(MWS721LF*S721HHLF)+(MWS721SF*S721HHSF)+(MWS722LF*
S722HHLF)+(MWS722SF*S722HHSF)

TMWWKG = IF((WC/8)=0) THEN STMW ELSE 0

TNLF = ROUND((POP-(TNSF*2))/LF)

TNP350S711LF = MAX(0, NEP350S711LF+FN350S711LF)

TNP350S711SF = MAX(0, NEP350S711SF+FN350S711SF)

TNP350S712LF = MAX(0, NEP350S712LF+FN350S712LF)

TNP350S712SF = MAX(0, NEP350S712SF+FN350S712SF)

TNP350S721LF = MAX(0, NEP350S721LF+FN350S721HHLF)

TNP350S721SF = MAX(0, NEP350S721SF+FN350S721SF)

TNP350S722LF = MAX(0, NEP350S722LF+FN350S722LF)

TNP350S722SF = MAX(0, NEP350S722SF+FN350S722SF)

TNP500S711LF = MAX(0, NEP500S711LF+FN500S711LF)

TNP500S711SF = MAX(0, NEP500S711SF+FN500S711SF)

TNP500S712LF = MAX(0, NEP500S712LF+FN500S712LF)

TNP500S712SF = MAX(0, NEP500S712SF+FN500S712SF)

TNP500S721LF = MAX(0, NEP500S721LF+FN500_S721LF)

TNP500S721SF = MAX(0, FN500S721SF+NEP500S721SF)

TNP500S722LF = MAX(0, NEP500S722LF+FN500S722LF)

TNP500S722SF = MAX(0, FN500S722SF+NEP500S722SF)

TNSF = ROUND((Max_PSF*POP)/SF)

Tomato = 90

Tomato_Trey_Cha_Cho_Em = 45

Total_waste = Household_waste+Retailer_waste

Trey_Cha_Cho_Em = Carrot+Capsicum_Trey_Cha_Cho_Em+Tomato_Trey_Cha_Cho_Em

TVNS111LF = ((FN350S111LF*P350)+(P500*FN500S111LF))*S111HHLF

TVNS111SF = ((FN350S111SF*P350)+(P500*FN500S111SF))*S111HHSF
TVNS112LF = ((FN350S112LF*P350)+(P500*FN500S112LF))*S112HHLF
TVNS112SF = ((FN350S112SF*P350)+(P500*FN500S112SF))*S112HHSF
TVNS121LF = ((FN350S121LF*P350)+(P500*FN500S121LF))*S121HHLF
TVNS121SF = ((FN350S121SF*P350)+(P500*FN500S121SF))*S121HHSF
TVNS122LF = ((FN350S122LF*P350)+(P500*FN500S122LF))*S122HHLF
TVNS122SF = ((FN350S122SF*P350)+(P500*FN500S122SF))*S122HHSF
TVNS1HHLF = TVNS111LF+TVNS112LF+TVNS122LF+TVNS121LF
TVNS1HHSF = TVNS111SF+TVNS112SF+TVNS121SF+TVNS122SF
TVNS411LF = ((FN350S411LF*P350)+(P500*FN500S411LF))*S411HHLF
TVNS411SF = ((FN350S411SF*P350)+(P500*FN500S411SF))*S411HHSF
TVNS412LF = ((FN350S412LF*P350)+(P500*FN500S412LF))*S412HHLF
TVNS412SF = ((FN350S412SF*P350)+(P500*FN500S412SF))*S412HHSF
TVNS421LF = ((FN350S421LF*P350)+(P500*FN500S421LF))*S421HHLF
TVNS421SF = ((FN350S421SF*P350)+(P500*FN500S421SF))*S421HHSF
TVNS422LF = ((FN350S422LF*P350)+(P500*FN500S422LF))*S422HHLF
TVNS422SF = ((FN350S422SF*P350)+(P500*FN500S422SF))*S422HHSF
TVNS4HHLF = TVNS411LF+TVNS412LF+TVNS421LF+TVNS422LF
TVNS4HHSF = TVNS411SF+TVNS412SF+TVNS421SF+TVNS422SF
TVNS711LF = ((TNP350S711LF*P350)+(P500*TNP500S711LF))*S711HHLF
TVNS711SF = ((TNP350S711SF*P350)+(P500*TNP500S711SF))*S711HHSF
TVNS712LF = ((TNP350S712LF*P350)+(P500*TNP500S712LF))*S712HHLF
TVNS712SF = ((TNP350S712SF*P350)+(P500*TNP500S712SF))*S712HHSF
TVNS721LF = ((TNP350S721LF*P350)+(P500*TNP500S721LF))*S721HHLF
TVNS721SF = ((TNP350S721SF*P350)+(P500*TNP500S721SF))*S721HHSF
TVNS722LF = ((TNP350S722LF*P350)+(P500*TNP500S722LF))*S722HHLF
TVNS722SF = ((TNP350S722SF*P350)+(P500*TNP500S722SF))*S722HHSF
TVNS7HHLF = TVNS711LF+TVNS712LF+TVNS722LF+TVNS721LF
TVNS7HHSF = TVNS711SF+TVNS712SF+TVNS722SF+TVNS721SF
TW = 4
TW24G = (SWLFG+SWSFG)
TWEPS711LF = SPWEPS711LF+SWEPS711LF
TWEPS711SF = SPWEPSS711SF+SWEPS711SF
TWEPS712LF = SPWEPSS712LF+SWEPS712LF
TWEPS712SF = SPWEPSS712SF+SWEPS712SF
TWEPS721LF = SPWEPSS721LF+SWEPS721LF
TWEPS721SF = SPWEPSS721SF+SWEPS721SF
TWEPS722LF = SWEPS722LF+SPWEPSS722LF

TWEPS722SF = SPWEPSS722SF+SWEPS722SF

TWP = (WPS111LF*S111HHLF)+(WPS111SF*S111HHSF)+ (WPS112LF*S112HHLF)
+(WPS112SF*S112HHSF)+(WPS121LF*S121HHLF)+(WPS121SF*S121HHSF)
+(WPS122LF*S122HHLF)+(WPS122SF*S122HHSF)+(WPS411LF*S411HHLF)
+(WPS411SF*S411HHSF)+(WPS412LF*S412HHLF)+(WPS412SF*S412HHSF)
+(WPS421LF*S421HHLF)+(WPS421SF*S421HHSF)+(WPS422LF*S422HHLF)
+(WPS422SF*S422HHSF)+(WPS711LF*S711HHLF)+(WPS711SF*S711HHSF)
+(WPS712LF*S712HHLF)+(WPS712SF*S712HHSF)+(WPS721LF*S721HHLF)
+(WPS721SF*S721HHSF)+(WPS722LF*S722HHLF)+(WPS722SF*S722HHSF)

TWPWKG = IF((WC/8)=0) THEN STWP ELSE 0

TWS111HHLF = (WS111LFG*S111HHLF)/UK

TWS111HHSF = (WS111SF*S111HHSF)/UK

TWS112HHLF = (WS112LF*S112HHLF)/UK

TWS112HHSF = (WS112SF*S112HHSF)/UK

TWS121HHLF = (WS121LF*S121HHLF)/UK

TWS121HHSF = (WS121SF*S121HHSF)/UK

TWS122HHLF = (WS122LF*S122HHLF)/UK

TWS122HHSF = (WS122SF*S122HHSF)/UK

TWS411HHLF = (WS411LF*S411HHLF)/UK

TWS411HHSF = (WS411SF*S411HHSF)/UK

TWS412HHLF = (WS412LF*S412HHLF)/UK

TWS412HHSF = (WS412SF*S412HHSF)/UK

TWS421HHLF = (WS421LF*S421HHLF)/UK

TWS421HHSF = (WS421SF*S421HHSF)/UK

TWS422HHLF = (WS422LF*S422HHLF)/UK

TWS422HHSF = (WS422SF*S422HHSF)/UK

TWS711HHLF = (WS711LF*S711HHLF)/UK

TWS711HHSF = (WS711SF*S711HHSF)/UK

TWS712HHLF = (WS712LF*S712HHLF)/UK

TWS712HHSF = (WS712SF*S712HHSF)/UK

TWS721HHLF = (S721HHLF*WS721LF)/UK

TWS721HHSF = (WS721SF*S721HHSF)/UK

TWS722HHLF = (WS722LF*S722HHLF)/UK

TWS722HHSF = (S722HHSF*WS722SF)/UK

UK = 1000

UM = 0.08

UVNS411LF = (FN350S411LF*P350)+(FN500S411LF*P500)

UVNS411SF = (FN350S411SF*P350)+(FN500S411SF*P500)

UVNS412HHLF = (FN350S412LF*P350)+(FN500S412LF*P500)
UVNS412SF = (FN350S412SF*P350)+(FN500S412SF*P500)
UVNS421LF = (FN350S421LF*P350)+(FN500S421LF*P500)
UVNS421SF = (FN350S421SF*P350)+(FN500S421SF*P500)
UVNS422LF = (FN350S422LF*P350)+(FN500S422LF*P500)
UVNS422SF = (FN350S422SF*P350)+(FN500S422SF*P500)
VNS111LF = IF (CDY/OAW) =INT(CDY/OAW) THEN (AVD*C1T1D*LF*OAW) ELSE 0
VNS111SF = IF (CDY/OAW) =INT(CDY/OAW) THEN (AVD*C1T1D*SF*OAW) ELSE 0
VNS112LF = IF (CDY/OAW) =INT(CDY/OAW) THEN (AVD*C1T2D*LF*OAW) ELSE 0
VNS112SF = IF (CDY/OAW) =INT(CDY/OAW) THEN (AVD*C1T2D*SF*OAW) ELSE 0
VNS121LF = IF (CDY/OAW) =INT(CDY/OAW)THEN (AVD*Cook_2T1D*LF*OAW) ELSE 0
VNS121SF = IF (CDY/OAW) =INT(CDY/OAW) THEN (AVD*Cook_2T1D*SF*OAW) ELSE 0
VNS122LF = IF(CDY/OAW) =INT(CDY/OAW) THEN (AVD*Cook_2T2D*LF*OAW) ELSE 0
VNS122SF = IF (CDY/OAW) =INT(CDY/OAW) THEN (AVD*Cook_2T2D*SF*OAW) ELSE 0
VNS411LF = IF (CDY/TW) =INT(CDY/TW) THEN (AVD*C1T1D*LF*TW) ELSE 0
VNS411SF = IF (CDY/TW) =INT(CDY/TW) THEN (AVD*C1T1D*SF*TW) ELSE 0
VNS412LF = IF (CDY/TW) =INT(CDY/TW) THEN (AVD*C1T2D*LF*TW) ELSE 0
VNS412SF = IF (CDY/TW) =INT(CDY/TW) THEN (AVD*C1T2D*SF*TW) ELSE 0
VNS421LF = IF (CDY/TW) =INT(CDY/TW) THEN (AVD*Cook_2T1D*LF*TW) ELSE 0
VNS421SF = IF (CDY/TW) =INT(CDY/TW) THEN (AVD*Cook_2T1D*SF*TW) ELSE 0
VNS422LF = IF (CDY/TW) =INT(CDY/TW) THEN (AVD*Cook_2T2D*LF*TW) ELSE 0
VNS422SF = IF (CDY/TW) =INT(CDY/TW) THEN (AVD*Cook_2T2D*SF*TW) ELSE 0
VNS711LF = AVD*C1T1D*LF
VNS711SF = AVD*C1T1D*SF
VNS712LF = AVD*C1T2D*LF
VNS712SF = AVD*C1T2D*SF
VNS721LF = AVD*Cook_2T1D*LF
VNS721SF = AVD*Cook_2T1D*SF
VNS722LF = AVD*Cook_2T2D*LF
VNS722SF = AVD*Cook_2T2D*SF
W350S111LF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N350S111LF-VNS111LF/P350)) *P350) ELSE 0
W350S111SF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N350S111SF-VNS111SF/P350)) *P350) ELSE 0

W350S112LF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N350S112LF-VNS112LF/P350))
*P350) ELSE 0

W350S112SF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N350S112SF-VNS112SF/P350))
*P350) ELSE 0

W350S121LF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N350S121LF-VNS121LF/P350))
*P350) ELSE 0

W350S121SF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N350S121SF-VNS121SF/P350))
*P350) ELSE 0

W350S122LF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N350S122LF-VNS122LF/P350))
*P350) ELSE 0

W350S122SF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N350S122SF-VNS122SF/P350))
*P350) ELSE 0

W350S411LF =IF (CDY/TW) =INT(CDY/TW) THEN ((N350S411LF-(EVNS411LF/P350))
*P350) ELSE 0

W350S411SF = IF (CDY/TW) =INT(CDY/TW) THEN ((N350S411SF-(EVNS411SF/P350))
*P350) ELSE 0

W350S412LF =IF (CDY/TW) =INT(CDY/TW) THEN ((N350S412LF-(EVNS412LF/P350))
*P350) ELSE 0

W350S412SF = IF (CDY/TW) =INT(CDY/TW) THEN ((N350S412SF-(EVNS412SF/P350))
*P350) ELSE 0

W350S421LF =IF (CDY/TW) =INT(CDY/TW) THEN ((N350S421LF-(EVNS421LF/P350))
*P350) ELSE 0

W350S421SF = IF (CDY/TW) =INT(CDY/TW) THEN ((N350S421SF-(EVNS421SF/P350))
*P350) ELSE 0

W350S422LF =IF (CDY/TW) =INT(CDY/TW) THEN ((N350S422LF-(EVNS422LF/P350))
*P350) ELSE 0

W350S422SF = IF (CDY/TW) =INT(CDY/TW) THEN ((N350S422SF-(EVNS422SF/P350))
*P350) ELSE 0

W350S711LF = (N350S711LF-(VNS711LF/P350))*P350

W350S711SF = (N350S711SF-(VNS711SF/P350))*P350

W350S712LF = (N350S712LF-(VNS712LF/P350))*P350

W350S712SF = (N350S712SF-(VNS712SF/P350))*P350

W350S721LF = (N350S721LF-(VNS721LF/P350))*P350

W350S721SF = (N350S721SF-(VNS721SF/P350))*P350

W350S722LF = (N350S722LF-(VNS722LF/P350))*P350

W350S722SF = (N350S722SF-(VNS722SF/P350))*P350

W500S111LF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N500S111LF(VNS111LF/P500))
*P500) ELSE 0

W500S111SF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N500S111SF(VNS111SF/P500))*P500) ELSE 0

W500S112LF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N500S112LF(VNS112LF/P500))*P500) ELSE 0

W500S112SF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N500S112SF-VNS112SF/P500))*P500) ELSE 0

W500S121LF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N500S121LF-VNS121LF/P500))*P500) ELSE 0

W500S121SF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N500S121SF-VNS121SF/P500))*P500) ELSE 0

W500S122LF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N500S122LF-VNS122LF/P500))*P500) ELSE 0

W500S122SF =IF(CDY/OAW)=INT(CDY/OAW)THEN((N500S122SF-VNS122SF/P500))*P500) ELSE 0

W500S411LF =IF (CDY/TW) =INT(CDY/TW) THEN ((N500S411LF-(EVNS411LF/P500))*P500) ELSE 0

W500S411SF = IF (CDY/TW) =INT(CDY/TW) THEN ((N500S411SF-(EVNS411SF/P500))*P500) ELSE 0

W500S412LF =IF (CDY/TW) =INT(CDY/TW) THEN ((N500S412LF-(EVNS412LF/P500))*P500) ELSE 0

W500S412SF = IF (CDY/TW) =INT(CDY/TW) THEN ((N500S412SF-(EVNS412SF/P500))*P500) ELSE 0

W500S421LF =IF (CDY/TW) =INT(CDY/TW) THEN ((N500S421LF-(EVNS421LF/P500))*P500) ELSE 0

W500S421SF = IF (CDY/TW) =INT(CDY/TW) THEN ((N500S421SF-(EVNS421SF/P500))*P500) ELSE 0

W500S422LF =IF (CDY/TW) =INT(CDY/TW) THEN ((N500S422LF-(EVNS422LF/P500))*P500) ELSE 0

W500S422SF = IF (CDY/TW) =INT(CDY/TW) THEN ((N500S422SF-(EVNS422SF/P500))*P500) ELSE 0

W500S711LF = (N500S711LF-(VNS711LF/P500))*P500

W500S711SF = (N500S711SF-(VNS711SF/P500))*P500

W500S712LF = (N500S712LF-(VNS712LF/P500))*P500

W500S712SF = (N500S712SF-(VNS712SF/P500))*P500

W500S721LF = (N500S721LF-(VNS721LF/P500))*P500

W500S721SF = (N500S721SF-(VNS721SF/P500))*P500

W500S722LF = (N500S722LF-(VNS722LF/P500))*P500

W500S722SF = (N500S722SF-(VNS722SF/P500))*P500

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WC              = MOD(COUNTER(0,10000),8)
WDS411LF        = DELAY ( SWS411LF, 4)
WDS411SF        = DELAY ( SWS411SF, 4)
WDS412LF        = DELAY ( SWS412LF, 4)
WDS412SF        = DELAY ( SWS412SF, 4)
WDS421LF        = DELAY ( SWS421LF, 4)
WDS421SF        = DELAY ( SWS421SF, 4)
WDS422LF        = DELAY ( SWS422LF, 4)
WDS422SF        = DELAY ( SWS422SF, 4)
WMEP350S721LF = NEP350S721LF*CWP*P350
WMLPS111LF   =IF(CDY/OAW)=INT(CDY/OAW)THEN(ABS(VNS111LF
                ((NM500LPS111LF*P500) +(NM350LPS111LF*P350)))) ELSE 0
WMLPS111SF   = IF (CDY/OAW) =INT(CDY/OAW)THEN
                (ABS(VNS111SF-((NM500LPS111SF*P500)+(NM350LPS111SF*P350))))
                ELSE 0
WMLPS112LF   = IF (CDY/OAW) =INT(CDY/OAW) THEN
                (ABS(VNS112LF-((NM500LPS112LF*P500)+(NM350LPS112LF*P350))))
                ELSE 0
WMLPS112SF   = IF (CDY/OAW) =INT(CDY/OAW)THEN
                (ABS(VNS112SF-((NM500LPS112SF*P500)+(NM350LPS112SF*P350))))
                ELSE 0
WMLPS121LF   = IF (CDY/OAW) =INT(CDY/OAW) THEN
                (ABS(VNS121LF-((NM500LPS121LF*P500)+(NM350LPS121HHLF*P350))))
                ELSE 0
WMLPS121SF   = IF (CDY/OAW) =INT(CDY/OAW)THEN
                (ABS(VNS121SF-((NM500LPS121SF*P500)+(NM350LPS121SF*P350))))
                ELSE 0
WMLPS122LF   = IF (CDY/OAW) =INT(CDY/OAW)THEN
                (ABS(VNS122LF-((NM500LPS122LF*P500)+(NM350LPS122LF*P350))))
                 ELSE 0
WMLPS122SF   = IF (CDY/OAW) =INT(CDY/OAW)THEN
                (ABS(VNS122SF-((NM500LPS122SF*P500)+(NM350LPS122SF*P350))))
                ELSE 0
WMLPS411LF   = IF (CDY/TW) =INT(CDY/TW) THEN
                (ABS(EVNS411LF-((NM500LPS411LF*P500)+(NM350_LPS411LF*P350))))
                 ELSE 0
WMLPS411SF   = IF (CDY/TW) =INT(CDY/TW) THEN
                (ABS(EVNS411SF-((NM500LPS411SF*P500)+(NM350LPS411SF*P350))))
```

ELSE 0

WMLPS412LF = IF (CDY/TW) =INT(CDY/TW) THEN

(ABS(EVNS412LF-((NM500LPS412LF*P500)+(NM350LPS412LF*P350))))

ELSE 0

WMLPS412SF= IF (CDY/TW) =INT(CDY/TW) THEN

(ABS(EVNS412SF-((NM500LPS412SF*P500)+(NM350LPS412SF*P350))))

ELSE 0

WMLPS421LF= IF (CDY/TW) =INT(CDY/TW) THEN

(ABS(EVNS421LF-((NM500LPS421LF*P500)+(NM350LPS421LF*P350))))

ELSE 0

WMLPS421SF= IF (CDY/TW) =INT(CDY/TW) THEN

(ABS(EVNS421SF-((NM500LPS421SF*P500)+(NM350LPS421SF*P350))))

ELSE 0

WMLPS422LF= IF (CDY/TW) =INT(CDY/TW) THEN

(ABS(EVNS422LF-((NM500LPS422LF*P500)+(NM350LPS422LF*P350))))

ELSE 0

WMLPS422SF= IF (CDY/TW) =INT(CDY/TW) THEN

(ABS(EVNS422SF-((NM500LPS422SF*P500)+(NM350LPS422SF*P350))))

ELSE 0

WMLPS711LF = ABS(VNS711LF-((NM500LPS711LF*P500)+(NM350LPS711LF*P350)))

WMLPS711SF = ABS(VNS711SF-((NM500LPS711SF*P500)+(NM350LPS711SF*P350)))

WMLPS712LF = ABS(VNS712LF-((NM500LPS712LF*P500)+(NM350LPS712LF*P350)))

WMLPS712SF = ABS(VNS712SF-((NM500LPS712SF*P500)+(NM350LPS712SF*P350)))

WMLPS721LF = ABS(VNS721LF-((NM500LPS721LF*P500)+(NM350LPS721LF*P350)))

WMLPS721SF = ABS(VNS721SF-((NM500_LPS721SF*P500)+(NM350LPS721SF*P350)))

WMLPS722LF = ABS(VNS722LF-((NM500LPS722LF*P500)+(NM350LPS722LF*P350)))

WMLPS722SF = ABS(VNS722SF-((NM500LPS722SF*P500)+(NM350LPS722SF*P350)))

WMMSPS722SF = ABS(VNS722SF-((NM350SPS722SF*P350)+(NM500SPS722SF*P500)))

WMSPS111LF= IF (CDY/OAW) = INT(CDY/OAW) THEN

(ABS(VNS111LF-((NM350SPS111LF*P350)+(NM500SPS111LF*P500))))

ELSE 0

WMSPS111SF= IF (CDY/OAW) =INT(CDY/OAW) THEN

(ABS(VNS111SF-((NM350SPS111SF*P350)+(NM500SPS111SF*P500))))

ELSE 0

WMSPS112LF= IF (CDY/OAW) =INT(CDY/OAW) THEN

(ABS(VNS112LF-((NM350SPS112LF*P350)+(NM500SP112LF*P500))))

ELSE 0

WMSPS112SF= IF (CDY/OAW) =INT(CDY/OAW) THEN

(ABS(VNS112SF-((NM350SPS112SF*P350)+(NM500SPS112SF*P500))))
ELSE 0

WMSPS121LF= IF (CDY/OAW) =INT(CDY/OAW) THEN
(ABS(VNS121LF-((NM350SPS121LF*P350)+(NM500SPS121LF*P500))))
ELSE 0

WMSPS121SF= IF (CDY/OAW) =INT(CDY/OAW) THEN
(ABS(VNS121SF-((NM350SPS121SF*P350)+(NM500SPS121SF*P500))))
ELSE 0

WMSPS122LF= IF (CDY/OAW) =INT(CDY/OAW) THEN
(ABS(VNS122LF-((NM350SPS122LF*P350)+(NM500SPS122LF*P500))))
ELSE 0

WMSPS122SF= IF (CDY/OAW) =INT(CDY/OAW) THEN
(ABS(VNS122SF-((NM350SPS122SF*P350)+(NM500SPS122SF*P500))))
ELSE 0

WMSPS411LF= IF (CDY/TW) =INT(CDY/TW) THEN
(ABS(EVNS411LF-((NM350SPS411LF*P350)+(NM500SPS411LF*P500))))
ELSE 0

WMSPS411SF= IF (CDY/TW) =INT(CDY/TW) THEN
(ABS(EVNS411SF-((NM350SPS411SF*P350)+(NM500SPS411SF*P500))))
ELSE 0

WMSPS412LF= IF (CDY/TW) =INT(CDY/TW) THEN
(ABS(EVNS412LF-((NM350SPS412LF*P350)+(NM500SPS412LF*P500))))
ELSE 0

WMSPS412SF= IF (CDY/TW) =INT(CDY/TW) THEN
(ABS(EVNS412SF-((NM350SPS412SF*P350)+(NM500SPS412SF*P500))))
ELSE 0

WMSPS421LF= IF (CDY/TW) =INT(CDY/TW) THEN
(ABS(EVNS421LF-((NM350SPS421LF*P350)+(NM500SPS421LF*P500))))
ELSE 0

WMSPS421SF= IF (CDY/TW) =INT(CDY/TW) THEN
(ABS(EVNS421SF-((NM350SPS421SF*P350)+(NM500SPS421SF*P500))))
ELSE 0

WMSPS422LF= IF (CDY/TW) =INT(CDY/TW) THEN
(ABS(EVNS422LF-((NM350SPS422LF*P350)+(NM500SPS422LF*P500))))
ELSE 0

WMSPS422SF= IF (CDY/TW) =INT(CDY/TW) THEN
(ABS(EVNS422SF-((NM350SPS422SF*P350)+(NM500SPS422SF*P500))))
ELSE 0

WMSPS711LF = (ABS(VNS711LF-((NM350SPS711LF*P350)+(NM500SP711LF*P500))))

WMSPS711SF = ABS(VNS711SF-((NM350SPS711SF*P350)+(NM500SPS711SF*P500)))

WMSPS712LF = ABS(VNS712LF-((NM350SPS712LF*P350)+(NM500SPS71LF*P500)))

WMSPS712SF = ABS(VNS712SF-((NM350SPS712SF*P350)+(NM500SPS712SF*P500)))

WMSPS721LF = ABS(VNS721LF-((NM350SPS721LF*P350)+(NM500SPS721LF*P500)))

WMSPS721SF = ABS(VNS721SF-((NM350SPS721SF*P350)+(NM500SPS721SF*P500)))

WMSPS722LF = ABS(VNS722LF-((NM350SPS722LF*P350)+(NM500SPS722LF*P500)))

WNEP350S711LF = NEP350S711LF*CWP*P350

WNEP350S711SF = NEP350S711SF*CWP*P350

WNEP350S712LF = NEP350S712LF*CWP*P350

WNEP350S712SF = NEP350S712SF*CWP*P350

WNEP350S721SF = NEP350S721SF*CWP*P350

WNEP350S722HHSF = NEP350S722SF*CWP*P350

WNEP350S722LF = NEP350S722LF*CWP*P350

WNEP500S711LF = NEP500S711LF*CWP*P500

WNEP500S711SF = NEP500S711SF*CWP*P500

WNEP500S712LF = NEP500S712LF*CWP*P500

WNEP500S712SF = NEP500S712SF*CWP*P500

WNEP500S721LF = NEP500S721LF*CWP*P500

WNEP500S721SF = NEP500S721SF*CWP*P500

WNEP500S722HHSF = NEP500S722SF*CWP*P500

WNEP500S722LF = NEP500S722LF*CWP*P500

WPEP350S711LF = ((NEP350S711LF*P350)-WNEP350S711LF)*PFP

WPEP350S711SF = ((NEP350S711SF*P350)-WNEP350S711SF)*PFP

WPEP350S712LF = ((NEP350S712LF*P350)-WNEP350S712LF)*PFP

WPEP350S712SF = ((NEP350S712SF*P350)-WNEP350S712SF)*PFP

WPEP350S721LF = ((NEP350S721LF*P350)-WMEP350S721LF)*PFP

WPEP350S721SF = ((NEP350S721SF*P350)-WNEP350S721SF)*PFP

WPEP350S722HHSF = ((NEP350S722SF*P350)-WNEP350S722HHSF)*PFP

WPEP350S722LF = ((NEP350S722LF*P350)-WNEP350S722LF)*PFP

WPEP500S711LF = ((NEP500S711LF*P500)-WNEP500S711LF)*PFP

WPEP500S711SF = ((NEP500S711SF*P500)-WNEP500S711SF)*PFP

WPEP500S712LF = ((NEP500S712LF*P500)-WNEP500S712LF)*PFP

WPEP500S712SF = ((NEP500S712SF*P500)-WNEP500S712SF)*PFP

WPEP500S721LF = ((NEP500S721LF*P500)-WNEP500S721LF)*PFP

WPEP500S721SF = ((NEP500S721SF*P500)-WNEP500S721SF)*PFP

WPEP500S722HHSF = ((NEP500S722SF*P500)-WNEP500S722HHSF)*PFP

WPEP500S722LF = ((NEP500S722LF*P500)-WNEP500S722LF)*PFP

WPS111LF = PFP*VNS111LF
WPS111SF = PFP*VNS111SF
WPS112LF = PFP*VNS112LF
WPS112SF = PFP*VNS112SF
WPS121LF = PFP*VNS121LF
WPS121SF = PFP*VNS121SF
WPS122LF = PFP*VNS122LF
WPS122SF = PFP*VNS122SF
WPS411LF = EVNS411LF*PFP
WPS411SF = EVNS411SF*PFP
WPS412LF = EVNS412LF*PFP
WPS412SF = EVNS412SF*PFP
WPS421LF = EVNS421LF*PFP
WPS421SF = EVNS421SF*PFP
WPS422LF = EVNS422LF*PFP
WPS422SF = EVNS422SF*PFP
WPS711LF = PFP*VNS711LF
WPS711SF = PFP*VNS711SF
WPS712LF = PFP*VNS712LF
WPS712SF = PFP*VNS712SF
WPS721LF = PFP*VNS721LF
WPS721SF = PFP*VNS721SF
WPS722LF = PFP*VNS722LF
WPS722SF = PFP*VNS722SF
WS111LFG = MWS111LF+WPS111LF
WS111SF = MWS111SF+WPS111SF
WS112LF = MWS112LF+WPS112LF
WS112SF = MWS112SF+WPS112SF
WS121LF = MWS121LF+WPS121LF
WS121SF = MWS121SF+WPS121SF
WS122LF = MWS122LF+WPS122LF
WS122SF = MWS122SF+WPS122SF
WS411LF = LS411LF+MWS411LF+WPS411LF
WS411SF = LS411SF+MWS411SF+WPS411SF
WS412LF = LS412LF+MWS412LF+WPS412LF
WS412SF = LS412SF+MWS412SF+WPS412SF
WS421LF = LS421LF+MWS421LF+WPS421LF
WS421SF = LS421SF+MWS421SF+WPS421SF

WS422LF = LS422LF+MWS422LF+WPS422LF

WS422SF = LS422SF+MWS422SF+WPS422SF

WS711LF = MWS711LF+WPS711LF+TWEPS711LF

WS711SF = WPS711SF+TWEPS711SF+MWS711SF

WS712LF = MWS712LF+WPS712LF+TWEPS712LF

WS712SF = MWS712SF+TWEPS712SF+WPS712SF

WS721LF = MWS721LF+TWEPS721LF+WPS721LF

WS721SF = MWS721SF+TWEPS721SF+WPS721SF

WS722LF = MWS722LF+TWEPS722LF+WPS722LF

WS722SF = WPS722SF+TWEPS722SF+MWS722SF

WTWHRWM = (Total_waste*UM)

WWM = (IF OCPNBD>0 THEN (WTWHRWM)-(PPNBD*CBD) ELSE 0)

BIOGRAPHY

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Publications

Sireiratana, T, & Thanwadee, C. (2018). Factors Influencing Food Waste Management in Phnom Penh, Cambodia: Data Collection. The 2018 3rd Technology Innovation Management *and Engineering Science International Conference*.