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# Reducing Food Waste: Strategies for Household Waste Management to Minimize the Impact of Climate Change and Contribute to Malaysia's Sustainable Development

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**Abstract.** The Food and Agriculture Organization (FAO) of the United Nations estimated, one-third of the food produced worldwide i.e. 1.3 billion tons is either lost or wasted throughout the food supply chain from primary production to final consumption. According to The Food Sustainability Index (FSI), the sustainable food system has three pillars namely food loss and food waste, sustainable agriculture and nutritional challenge. Food waste can be classified into food products that are lost during the production phase, unavoidable food waste that lost during the consumption phase and avoidable food waste that could have been eaten but lost during the consumption phase. There are several popular treatment methods of food waste that have been widely applied in developing countries including animal feeding, composting, anaerobic digestion, incineration, and landfills. The common treatment of food waste in developing countries is dumping or landfills. About 95% of food waste ends at landfill sites in which food waste is converted into methane and other greenhouse gases that affect climate change. Therefore, reducing food waste contributes to abating interlinked sustainability challenges including food waste and food safety, climate change and stress to natural resources. This paper sets out recommendations on how to reduce food waste generation by using six strategies that are food waste separation or composting behavior, eating behavior, cooking behavior, consumer's environmental knowledge of food waste, consumer's environmental awareness and government policy on household food waste management, which can contribute to the nation's goal for sustainable development.

## 1. Introduction

Every year approximately 1.3 billion tons of food or equal to 1 over 3 of everything produced is wasted as proved by The Food and Agriculture Organization (FAO) of the United Nations either lost or wasted throughout the food supply chain from primary production to final consumption [6];[14]. According to The Food Sustainability Index (FSI), a sustainable food system has three pillars including food loss and



food waste, sustainable agriculture and nutritional challenge. Surprisingly in developed countries, the major contribution to food waste originates from households [15].

According to Gustavsson, Cenderberg & Sonesson [6], food is wasted throughout the food supply chain from initial agricultural production down to final household consumption. In medium and high-income countries, food is high extent wasted by thrown away, even if it is still suitable for human consumption. Meanwhile, in low-income countries, food is lost during the production and processing stages of the food supply chain. There are few studies on the topic of food waste and it is associated with consumer behavior but still remains neglected and failed to present a broader view of the problem [3]. Human behaviors influence food waste in various aspects of food's journey into and through home. For example; planning, shopping, storage, preparation and consumption of food.

Quested et al. [16] estimated methane gas and other greenhouse gasses that affected climate change caused by 95% of food waste that ends up at landfill sites. Therefore, reducing food waste may abate interlinked sustainability challenges including food waste, food safety, climate change and stress to natural resources. Also according to Hebrok & Boks [7], tackling food waste appears as one of the key issues associated with sustainable development.

This paper outlines recommendations on how to reduce food waste generation at households level by using six strategies including food waste separation or composting behavior, eating behavior, cooking behavior, consumer's environmental knowledge of food waste, consumer's environmental awareness and government policy on household food waste management towards sustainable development.

## **2. Food Waste**

Food waste is defined as food produced for human consumption but has discarded or was not consumed by humans. This included food that spoiled prior to disposal and food that was still edible when thrown away [20]. Moreover, a fraction of food and inedible parts of food, removed from the food supply chain to be recovered, disposed including composted, crops plowed harvested, anaerobic digestion, bioenergy production, cogeneration, incineration, disposal to sewer, landfill or discarded to the ocean is also categorized as food waste [21]. However, a definition of food waste given by the United States Environmental Protection Agency (USEPA) is uneaten food and food preparation wastes from residences, commercial, and institutional establishments. Hence, food wastes from homes, grocery stores, restaurants, bars, factory lunchrooms and company cafeterias are also included. However, pre-consumer food waste generated during food manufacturing and packaging is excluded [20].

Nevertheless, food waste can be differentiated with food losses because food losses described as an edible food mass throughout a part of the supply chain that specifically leads to edible food for human consumption [20]. Both food losses and food waste refer to food items intended for human consumption and include in both types avoidable and unavoidable waste also related to behavior [21]. Explaining by Thyberg & Tonjes [20] in their study, food wastage is not the result of a single behavior but it describes as combinations of multiple behaviors. Cultural, political, economic, geographic and socio-demographic drivers described that may cause the behaviors, but can personal preference, values, and attitudes.

A study by Porpino, Parente & Wansink [14] depicted that source of household food waste comes from inappropriate food conservation from storage, leftovers after consumption, over-preparation, and excessive purchase from stocking and buying as shown in Figure 1. Household food waste defined as sources of food and drinks that are consumed within the home includes retail and contributions from home-grown food and takeaways [13]. According to Graham-Rowe [5], in high-income countries, the largest contribution to food waste comes from the consumer. In low-income countries losses early in the food chain are more common, due to low technological support in the management of crops, lack of structure for storing produce and inadequate infrastructure for the distribution of crops [14]

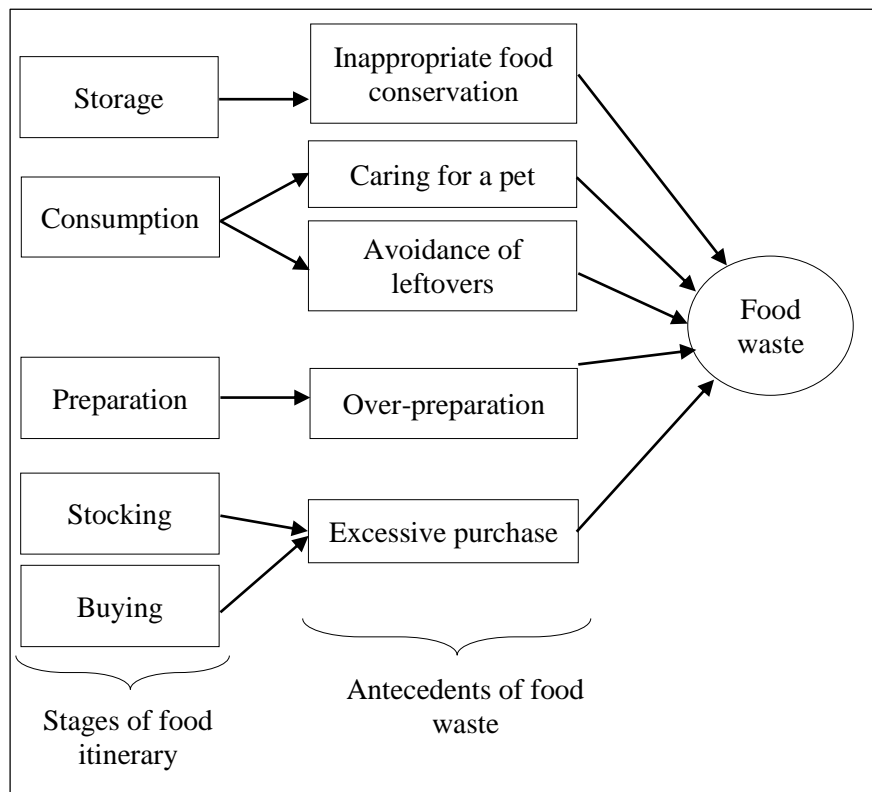


Figure 1. Integrated Model of Household Food Waste: Itinerary stages and Antecedents.

### 2.1. Types of Food Waste

According to Garcia-Garcia et al. [4], in 2014 the European Commission has classified food waste into three categories food losses:

- food products lost during the production phase
- unavoidable food waste is referring to food products lost during the consumption phase (example: banana peels, fruit cores)
- avoidable food waste is products that could have been eaten but was lost during the consumption phase

Meanwhile, Parfitt, Barthel & Macnaughton [13] classified household food waste into avoidable, possibly avoidable and unavoidable. First, avoidable food waste as food and drink are discarded at some point prior to disposal, edible in the vast majority of situations. Then, possibly avoidable food waste as food and drink that some people eat and others do not or can be eaten when a portion of food is prepared in one way but not in other ways such as potato skins. Finally, unavoidable food waste as waste arising from food preparation that is not and has not been edible under normal circumstances.

### 2.2. treatment Methods

There are five prevalent treatment methods of food waste that have been widely applied in developing countries including animal feeding, composting, anaerobic digestion, incineration, and landfills [20]. The common treatment of food waste in developing countries is dumping or landfills. However, according to Quested et al. [16] about 95% of food waste ends at landfill sites, that converted into methane and other greenhouse gasses that affect climate change [16]. Somehow, anaerobic digestion

and vermicomposting have the capability to transform food waste into more valuable products such as biogas and organic fertilizers [9]. Meanwhile, composting can be achieved by individuals at home or by community composting schemes. Composting is a method that can remove waste from landfills or incineration and creates a product that can then be used again as a soil nutrient, mulch or cover for completed landfill sites also useful in improving the soil.

According to Parfitt, Barthel & Macnaughton [13] for landfills, to create a site that is suitable for landfills, a number of factors have to be taken into consideration such as the location of the site and its geology and hydrogeology. Landfill sites can also act as breeding grounds for pests like rats which can be a vector for human diseases. Moreover, consideration to build landfills also includes how to reduce leachate and gas formation also to ensure protection against flooding and how waste can be covered or capped. Therefore, the site has to be monitored to ensure it is safe to operate and this also applies when it has been decommissioned.

Many countries are now using financial and legislative measures, such as Landfill Taxes, and the Packaging Regulations to target local authorities and those responsible for municipal and industrial waste. The aim is to reduce the amount of rubbish and encourage recycling and waste minimization. Some countries implemented regulation such as consumer have to pay for each bag of rubbish produced, so that they reduce the amount they dispose of and recycle or compost materials that would otherwise be thrown away [6].

### **3. Impact of Climate Change**

Methane (CH<sub>4</sub>), the most abundant and stable hydrocarbon gas in the atmosphere plays an important role in the photochemistry of the background troposphere. According to Graham-Rowe [5], advances in household waste management methods and technologies and also awareness of climate change and carbon emissions have led to many changes in the management of household waste. United Nations Framework Convention on Climate Change (UNFCCC) stated climate change refers to a change greater than natural climate variability observed over a comparable period of time-in climate status; this variation is attributable to an alteration in the composition of the global atmosphere directly or indirectly caused by human activity [16].

According to Karim Ghani et al. [9], food wastes are sent to landfills, which would degrade in anaerobic conditions to release methane as a potent greenhouse gas. Land-filled food waste can produce methane gas that results in 21 times greater impact on global warming than carbon dioxide. Moreover, an important aspect related to the impacts of municipal solid waste management is the waste management sector as a contributor to the anthropogenic emission of methane that is a powerful greenhouse gas (GHG) with a global warming effect about 25 times higher than carbon dioxide and it is due to the anaerobic decomposition of the organic fraction of waste in disposal sites [1].

### **4. Sustainable Development**

Sustainable development provides an integrated and holistic view of economic development, social development, and environmental protection. Sustainable development came into the forefront of the international arena in the early 1990s with the United Nations Conference on Environment and Development (UNCED) known as the “Earth Summit” held in Rio de Janeiro Brazil in 1992 [11]. Meeting the needs of the present generation without compromising the ability of future generations to meet their needs is another familiar definition of sustainable development given by The World Commission on Environment and Development in 1987. These needs include food, work, shelter and health care for all the population and they must provide in a manner that prejudices none of them otherwise preserves the environment and its resources [10].

Two concepts and terms important for sustainable development are The Rio Principles and Agenda 21. According to LESTARI [11], The Rio Principles provide an internationally agreed foundation of the concept of sustainable development and there are 27 principles that have been focused on sustainable development. The principles clarify that sustainable development as a human-centered concept, people are entitled to a healthy and productive life in harmony with nature. These also stress that sustainable development is concerned with both intra and intergenerational equity. While Agenda 21 as a blueprint for achieving sustainable development. It has forty chapters in different sections, social and economic dimensions, conservation and management of resources for development meanwhile to strengthening the role of major groups and means of implementation. The actors for these actions have been mentioned as governments, industry and international organizations [12]. In ‘Sustainable Development Goals’ (SDG) in 2015, food waste identified as a food waste and loss as important challenges for achieving sustainable consumption, and Goal 12.3 aims to “By 2030 halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses” (UNEP 2015).

## 5. Strategies to Reduce Food Waste

Reduce food waste at households is the choice to implement the strategies to disposing food at home meanwhile give benefits to the environment. In the first place, the largest environmental benefit comes from preventing food from being wasted. As mentioned by Queded et al. [15] by reducing the food waste in a same time it can to reduce the energy, water and other resources used to grow, harvest, transport, process and sell the food, as well as emissions associated with storage and cooking in the home.

### 5.1. Food waste separation or composting behavior

Basic habit for food waste separation is recommended to sort with other household wastes. Separate the food waste bins at homes may also help to increase awareness among consumers. Meanwhile, it is easier and safe for a scavenger to collect waste. According to Karim Ghani et al. [9], waste separation is behavior that requires considerable efforts on the part of the individual as household waste must be sorted, prepared and stored.

Meanwhile, composting is a biological decomposition of organic waste either in an aerobic or anaerobic environment with the former being more common. These processes lead to pollution such as the greenhouse effect because those organic materials were built photosynthetic. Both processes are sustainable processes in terms of economic aspects as they involve lower operating costs compare to other waste management options and produce excellent agricultural soil amendments [22]. Home composting that has been used widely and home-friendly is Takakura Method or called home composting. Takakura composting method is organic waste that is broken down by micro-organisms that are cultivated from local materials [12]. The method involves making a seed compost from fermented solutions involved sugar fermentation solution and salt fermentation solution also a fermenting bed that made from mix equal of rice bran and rice husk. Organic waste is mixed with the seed compost and left to degrade in a ventilated container or basket. Basically, this is an easy method that can be practicing in every household in Malaysia. There are 3 important factors of composting: microorganisms, moisture control and aerobic that is presence of oxygen [12].

### 5.2. Cooking behavior

Plan a meal in advance before start cooking. These include making a shopping list and check the stock in the kitchen cabinet. According to Stefan et al. [19], planning routines example like checking inventory, making shopping lists, planning meals ahead actually will reduce the amount of food wasted, while certain shopping routines example like buying too much food or unintended products should have the opposite effect. Moreover, making shopping lists or planning meals in advance may also help consumers to decrease unplanned purchases and limit food waste [19]. According to the survey that has been done

by Jörissen, Priefer & Brautigam [8] more than 40% of food that is thrown away sometimes or often relates to fruit, vegetables and bread. Another reason why food is being wasted is due to outdated, stays in the fridge for long period and smelt or tasted bad and moldy.

### *5.3. Eating behavior*

Eating behavior that reflects more on sustainable production, such as buying products that are fair trade, eco-labeled, organic, as well as reducing their overall consumption, such as avoiding overeating and junk food. Eating behavior also focuses on how we serve our meal on the plate also the size of the plate that used. Because this is one of the factors may influence our appetite to finish up our meal. Therefore, smaller servings have shown to be effective in reducing the amount of food waste [18]. Issues of food quantity and quality may pose risk to food security, whereby eating behavior leads to overeating, irregular eating, imbalanced diet and taking unclean or contaminated food. As observed by Ali & Abdullah [2], the new practices of eating can be identified and categorized in terms of place of eating, time of eating, food types and the eateries themselves.

### *5.4. Consumer's environmental knowledge of food waste*

Reducing food waste at households could be done by the government or an organization to raise further knowledge whether related to economic, ecological or social to reducing food waste. For example, an educational program should be recommended in which greater awareness of food waste issues could help the consumer in seeing the whole picture. Nevertheless, according to a study by Selin [18], different knowledge in food waste management could further influence the habits and beliefs of food waste and ways to manage it. Moreover, according to Ali & Abdullah [2] educating the public about healthy eating, together with social responsibility among food entrepreneurs and good governance by every local authority are important factors for quality of life in urban communities. This knowledge and involvement have been established as the important factors that could alter an individual's behavior in preventing food waste [17].

### *5.5. Consumer's environmental awareness*

Education awareness on food waste in schools and political initiatives are possible starting points to change people's attitudes towards the current massive food waste [6]. High demand for products from food waste such as compost is one of food waste separation and minimization awareness programs that have been implemented in many developed countries [9]. The level of consistency between environmental attitudes and behavior is affected by a person's knowledge and awareness, public verbal commitment and his or her sense of responsibility. campaigns should be aimed at influencing consumers' practices related to food, such as changing their planning and shopping routines. According to Stefan et al. [19], changing people's attitudes towards food waste would have an effect on food waste as well as affected by their routines related to planning and shopping for food.

### *5.6. Government policy on household food waste management*

According to Gustavsson, Cenderberg & Sonesson [6], waste prevention requires changes in people's behavior both for companies and individuals. So, policy approaches should be multi-faceted and address attitudes and logistical aspects of waste prevention. Moreover, a package of prevention policies that are necessary to prevent food waste should encompass three key aspects that are values, skills, and logistics [20]. In Malaysia, National Solid Waste Management Policy 2016 is the latest version of policy in 2006 which maintains the main principle, establishing a comprehensive, integrated, effective cost, sustainable and acceptable for the public while reducing solid waste generation through 3R (reduce, reuse, recycle). There are 6 cores emphasized in this policy, and the third core focusing on strengthening the governance, legislative regulation, and law enforcement. Concept of 3R, waste management hierarchy, waste to energy and waste to wealth are the main target in each policy, regulation or law that involve society to achieve sustainable development meanwhile to minimize food waste from each household in Malaysia.

## 6. Conclusion

Reducing food waste contributes to abating interlinked sustainability challenges including food waste and food safety, climate change and stress to natural resources. There are several solutions to fix food waste at household and no policy measures to address it should be custom-tailored like involvement from each individual situation, integrate community needs, and involve values, skills, and logistics. Therefore, this paper conclude the recommendations on how to reduce food waste generation at household by using six strategies including food waste separation or composting behavior, eating behavior, cooking behavior, consumer's environmental knowledge of food waste, consumer's environmental awareness and government policy on household food waste management towards sustainable development.

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