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The Methodology to Evaluate Food Waste Generation with Existing Data in Thailand

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Abstract

According to the Sustainable Development Goal 12.3, there is a target to reduce global food loss and waste by 50 percent, by 2030. Currently, Thailand does not have a food waste database or food waste index reports that employ highly accurate methods of measurement. So, tackling the amount of food waste generation is a top priority and challenge in achieving the SDG target. This research aims to present a method that can be adapted to report the amounts of food waste based on available data constraints and a systematic review of the literature, in comparison with the UNEP food waste index report. Due to the limited availability of food waste data in Thailand, especially at household, food service, and retail levels, this study uses level 1 modeling to estimate food waste generation occurring at the national level. These data are based on municipal solid waste (MSW) volumes and organic waste composition. As reported by the Pollution Control Department, organic waste, accounting for 63.57 percent total of garbage, was collected by municipalities across the country. The result showed that the level 1 food waste index of Thailand was 167 kg/capita/year, a value lower than that reported by UNEP. The UNEP Food Waste Index Report 2021 provides a household food waste measure in Thailand of 79 kg/capita/year. The limitation of the estimated calculation of the level 1 food waste index is that the total amount of food waste cannot be classified by sector (households, food service, and retail), material type including edible part (human consumption), and inedible parts (bones, rinds, etc.), and the destinations. The level 2 and level 3 food waste indices both consist of the quantification and qualification of waste by sector, material type, and destinations. On the other hand, the quantification methodology of measurement should be combined with methods that gather more comprehensive information, up to the level of accuracy that includes access to the physical food waste being quantified. The results from this study led to a recommendation to define and select the appropriate methodology of measurement for food waste quantification and disaggregation depending on the main purpose, specific conditions, the technology available. These existing resources are key to tracking and monitoring progress towards the achievement of the food waste reduction targets.

Keywords : Food waste; Methodology; Quantification; Sustainable Development Goal 12.3

Introduction

Almost one-third of the food produced for human consumption around the world is lost or wasted along the food supply chain [1]. More than 931 million tons of food waste were created globally in 2019 representing one of the main sources of greenhouse gas emissions from human activities [2]. Global food loss and food waste (FLW) contribute approximately 4.4 $GtCO_2eq$ emissions each year, or 8 percent of total human greenhouse gas emissions. South and Southeast Asia, including Thailand, are responsible for a carbon footprint of food wastage of 350 kg CO_2 of GHG emissions per person [3]. The Sustainable Development Goals target 12.3 (SDG 12.3) aims to reduce global food loss and waste along the food supply chain by 50 percent, by 2030. Two indicators are tracked; Indicator 12.3.1(a); the Food Loss Index refers to measures at the production, post-harvest, and processing stages of the food supply chain excluding retail; and Indicator 12.3.1(b) the Food Waste Index, measures food waste that occurs at the retail, food service, and household level. The UNEP Food Waste Index Report 2021 announced Thailand produced an average baseline of 79 kg of food waste per capita per year, compared with the household food waste generation in ASEAN countries, in the range from 76 to 91 kg/capita/year. Vietnam averages 76 kg/capita/year, one of the lowest rates, and the highest level of food waste in South-eastern Asia is Malaysia at 91 kg/capita/year.

To achieve the Sustainable Development Goals target for reducing food waste (FW), data need to be collected that will measure exactly how much baseline food waste there is, along with monitoring that supports the prioritization of recommended actions and policies. Currently, Thailand does not have a food waste database or an accurate method of measurement used in the food waste index reports. Therefore, tackling the amount of food waste generated is a top priority and challenge in achieving the target. In Thailand, the volume of municipal waste is increasing significantly every year. The Pollution Control Department [4] reported that 63.57 percent of the total waste sent to landfills was organic waste. Also, the Bangkok Metropolitan Administration reported that an annual average of 46 percent (2011–2018), or around 4,284 tons in 2020, of total solid waste, is food waste [5], which is not a clear representation of the food waste index for the rest of Thailand. Therefore, tackling food waste generation with appropriate methods that have a high accuracy of measurement is a top priority and challenge in achieving the SDG target.

The limitations of the current qualitative data are the lack of availability of data on the national amount of food waste. The purpose of this paper is to provide a method for the country to report the available data on the quantity of food waste. This will include comparing the calculated results with the Food Waste Index Report 2021 values, from the United Nations Environment Programme (UNEP). In addition, appropriate statistical methods and estimators are suggested for highly accurate and reliable small-scale estimates of direct measurement methods.

Materials and Methods

The FW evaluation of the food loss and waste protocol has been adopted in this study. FLW Protocol Steering Committee published the food loss and waste accounting and reporting standard (FLW Standard) [6] that provided the requirements, steps to guide the preparation of an FLW inventory, and the principles of accounting and reporting for governments, companies, and other entities. The four components of FLW Protocol scope are based on the time frame, material type (classified as food, edible part, inedible parts, or both), the destination once removed from the food supply chain (Animal feed, bio-based materials/biochemical processing, co-digestion/ anaerobic digestion, composting/aerobic processes, controlled combustion, landfill, and wastewater treatment), and finally the external elements of the food category, life cycle stage, geography, and organization.

The definition of Food Waste (FW) is defined as any substance, drink that is intended for human consumption includes edible parts and inedible parts measures at retail, food service, and households while, Food Loss (FL) is defined as along production and supply chains, including

post-harvest losses [2, 7]. The composition of municipal solid waste (MSW) is food waste, garden waste, paper, wood, rubber/leather, cloth, plastic, foam, metal and aluminum, glass, hazardous waste from the community, electronic waste, infectious waste, and others. FW is defined as a classification of municipal solid waste composition into 12 categories consisting of vegetable scraps, meat scraps, bones, fruit peels, including scraps of raw materials discarded from cooking and discarded food waste excludes any packaging such as banana leaves, plastic bags, film sheets, foam trays, grilled skewers [8].

In the Guidance on FLW Quantification Methods by FLW Protocol [9], there are 10 quantification methods: direct measurements, counting/scanning, assessing volume, waste composition analysis, records, diaries, surveys, mass balance, modeling, and proxy data. Consequently, selecting the most appropriate method for data collection is very important due to the lack of existing data in the Thailand context. The amount of food waste in the national report can be estimated based on the total mass of the municipal solid waste. This indicator is measured by the total amount of food that is wasted in tons, or in terms of the percentage of what is considered to have no economic value and what is food packaging.

The UNSTATS [10] suggests a flexible three-level approach to presenting a methodology that is consistent and comparable information can be compared at regional levels. For level 1, the global model approach will estimate the proportion of food waste in the total waste stream data and municipal solid waste, and then apply the proportion to the total food waste to the existing information. Level 2-3 should identify the scope of which stages of each food supply chain are generated by retail, food service, and household sector. This will be further also divided by material type (edible part, inedible part) and destinations such as animal feed, anaerobic digestion, and landfill.

This study was collected the existing quantitative data from national statistics national of municipal solid waste (MSW) which generated from households, retail, food service, and office buildings and institutions, also the proportion of organic waste fraction, population statistics, and the proportion of household sector. The food waste estimates at level 1 can be calculated by equation (1).

$$FW = \frac{MSW \times f_{ow}}{pop} \times f_{HH} \quad (1)$$

Where FW is the food waste estimates in kilograms (kg) per capita per year, MSW is the municipal solid waste of the country in tons per year, f_{ow} is the proportion of organic waste fraction in percentage, pop is the number of populations, and f_{HH} is the proportion of household sector.

Results and Discussion

The FLW quantification methods provide 10 methods for collecting primary data and secondary data. The best way is to consider the appropriate methods is to find a balance between robustness and feasibility [11]. The terms of robustness refer to primary data, time series, representativeness, data validation, and uncertainty; whilst feasibility refers to cost or budget, data availability, time, and personnel. The most important criteria are based on goal collect data and waste management scheme in the destination. For example, if the objective is to reduce the total annual food waste by focusing on the waste management at the destination, then the most accurate way to collect data would require direct measurements that cover all seasons, which would require the investment of money, labor, and time. In contrast, if the objective is to provide policies to solve hot spot problems, then the money and time needed to classifying food waste into many complicated categories will increase greatly.

This study provides a feasibility assessment for food waste accounting through comparing the primary data and secondary data collection methods.

1. Calculation with existing data

Apart from the lack of a food waste database with high accuracy methods of measurement, the estimated food waste from secondary sources can be collected from public information provided by government statistics.

The proxy data can be extrapolated to infer quantities, using a mathematical approach that results in a quick estimate. The resulting estimates will be inaccurate but typically costs less than using actual measurements.

According to UNEP the accepted method for national reporting at Level 1 is based on estimations of the proportion of the total food waste from municipal solid waste (MSW) gathered from the accommodation, food services, manufacturing, and retail trade sources. In 2019, the Pollution Control Department (PCD) [12] reported a total generation of municipal solid waste of 28.71 million tons, of which food waste accounted for 63.5%, while the Environment Department, Bangkok Metropolitan Administration (BMA) reported it as 46% (the average of data during 2011–2018) [5], as shown in Table 1. FW contributes a huge portion in the MSW, makes from 59 to 70% of the MSW depending on the city [12]. However, there are some reports by the local municipalities that showed that FW was estimated lower than that of PCD reported. For example, in Samut Songkram Province [13], food waste accounting for 30.3% of total municipal solid waste, consists of rice and bakery 28%, fruit and vegetable 22%, leaf scraps/banana leaf for wrapping food 18%, meat 25%, and other 7.4%. In Phra Nakhon Si Ayutthaya, reported that an average food waste shared about 29.4% of total MSW in 2021; the highest proportion of FW in MSW was in the Subdistrict Administrative Organization (41.4%), followed by Town Municipality (28.5%), Subdistrict Municipality (26%), and City Municipality (21.7%) [14]. Moreover, Surin Town Municipality showed that the FW contributed 39.2% of total MSW in 2019 [15].

The result showed that the food waste index was calculated by using the PCD data based on the MSW generated and the proportion to the total food waste was 167 kg/capita/year in 2019, but when looking at the proportion to the total food waste calculated by the Environment Department, BMA was 121 kg/capita/year. When compared the result with the UNEP food waste index report 2021, this study reported higher levels than the UNEP reported due to the organic waste proportion in MSW, including both food waste, leaves, weeds, twigs, grass, and shrubs. The UNEP reported that the household food waste in Thailand was 79 kg/capita/year in 2019 and the proportion of global averages of generated food waste classified by sectors was: 61% from households, 26% from food service, and 13% from retail, and 14% is lost from food production [16].

The estimated household food waste of Thailand during 2010-2019 has increased continuously every year, as shown in Table 2 and Figure 1. When comparing the total food waste results of this study with the household food waste in developed countries in Asia: in Korea [17], the result indicated that the food waste of Thailand was higher than that of the household food waste in Korea (95 kg/capita/year). This is due to the Korea case study using the direct measurement method and considering the influent factor of seasonality and housing types while this study uses the organic waste composition to estimate the total food waste. In addition, Elimelech et al. [18] reported that the household food waste in Israel is 96.2 kg/capita/year, which accounts for 45% of the household waste composition. Moreover, Liu [19] shows that household food waste in Japan is 96.2 kg/capita/year using the statistical data and calculation method, which accounts for 29% of the household waste composition. Segrè et al. [20] presented that food waste by household in industrialized Asia countries are 80–90 kg/capita/year, while this figure in South and Southeast Asia is only 10–20 kg/capita/year. On the other hand, comparing the household food waste in developing countries in Asia: in Vietnam and Cambodia [21], the household food waste is 190 and 146 kg/capita/year, respectively as shown in Table 3.

Table 1 Lists national data relating to evaluating household food waste with existing data

Year	Detail	Amount	Reference
2019	Total generation of municipal solid waste	28.71 million tons	The Pollution Control Department (PCD) [4, 12]
	The proportion of the food waste in municipal solid waste	63.57%	
	Total population of Thailand (Excluding non-registered population)	66.5 million	National Statistical Office [22]
	The proportion of global averages of generated food waste classified by sectors: Households	61%	UNEP [2]
	Food waste index in Household level	167 kg/capita/year	Evaluate food waste generation with existing data

Table 2 Household food waste estimation from municipal solid waste of Thailand in 2010-2019

Detail	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Population (Million people)	65.98	64.08	64.46	64.79	65.12	65.73	65.93	66.19	66.41	66.56
Amount of MSW (Million tons)	24.22	25.35	24.73	26.77	26.19	26.85	27.06	27.37	27.93	28.71
Amount of Food Waste (Million tons)	15.40	16.11	15.72	17.02	16.65	17.07	17.20	17.40	17.75	18.25
Household Food Waste (63.5%) (kg/capita/year) [4]	142	153	149	160	156	158	159	160	163	167
Household Food Waste (46%) (kg/capita/year) [5]	103	111	108	116	113	115	115	116	118	121

Remark: [4] The Pollution Control Department (PCD); [5] Bangkok Metropolitan Administration

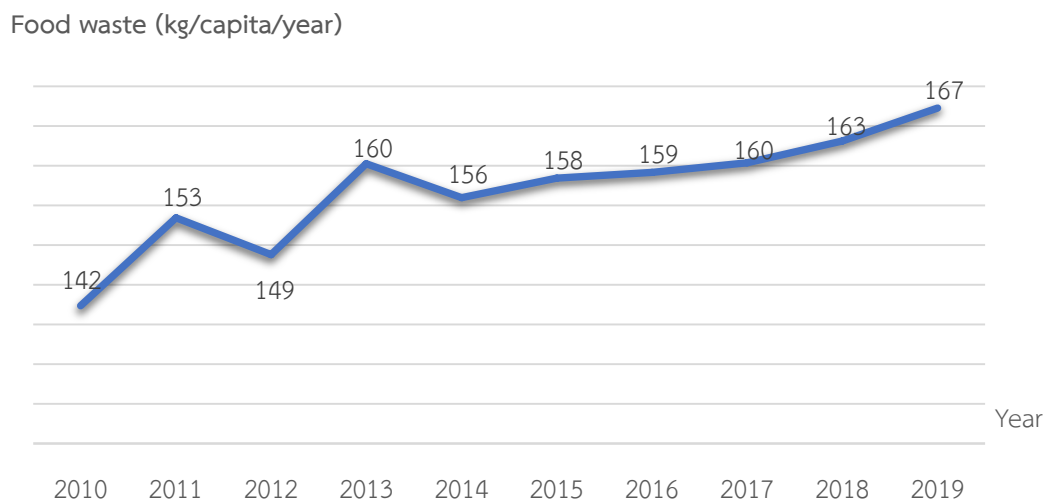

Figure 1 Household food waste estimation of Thailand in 2010-2019

Table 3 The comparing the household food waste in Asia

Country	Amount (kg/capita/year)	Year	Method
Thailand (this study) based on FW 63.57% of total MSW	167	2019	Estimation with existing data.
Thailand (Bangkok) based on FW 46% of total MSW	121	2019	Estimation with existing data.
Thailand reported by UNEP	79	2019	Extrapolating data from other countries [2]
South Korea	95	2019	Direct measurement [17]
Israel	96.2	2016	Weighing method [18]
Japan	48.9	2014	Calculated from the statistical data [19]
Vietnam (Da Nang)	190	2018	Literature data [21]
Cambodia (Phnom Penh)	146	2015	Literature data [21]
Industrialized Asia	85	2012	Literature data [20]
South & Southeast Asia	10-20	2012	Literature data [20]

2. Case studies

The conception of a global measurement method and report in levels 2-3 have been applied in a few studies in Thailand. A small study based on the urban community in Pathum Thani province focused on food waste generated at the consumer stage of the food supply chain. The data collection process from households, such as types of wasted food and the amount of food disposed of, were collected through voluntary participants weighing and recording food waste that they disposed of in a bin separate from other general municipal waste in order to separate the waste into animal feed (fish and dog feed) or landfill. Direct measurements are highly accurate if calibrated and proper measurements are used, but the disadvantages of weighing are the amount of effort and costs involved. Weighing total food waste and measuring the amount (weight) per food category requires separation from the packaging, non-catering waste, liquid waste, and moisture content of FW. This more detailed attempt will classify different types of food waste according to food categories.

This result showed that the direct measurement and sorting analysis of the household food wastage (direct weighing, waste composition analysis, and recording) were feasible in the testing of the methodology for a small sample in an urban community. It should be noted that food waste can be separated from MSW for the small communities. However, our study showed that the classification the food waste based on the universal standard, as the edible part and inedible part, was impossible. This was due to the limited funding, the time-consuming nature of it, the diverse mix of food items resulting in difficulty to classify, and the concept of avoiding food waste due to distinction in food customs. Moreover, the categorization of food waste into five food categories groups of cereals, fruits and vegetables, meat, tuber crop, and others can be unclear and the classification scheme difficult to understanding. Uncertainty in data is very important and thus the study should select an appropriate representative sample size to collect the data whilst dealing with nonresponse biases.

3. Discussion

Our findings showed data collection at the destination is more complex than at the source because separating many sources from large piles of waste brings problems for staff due to the fact that high temperatures and humidity throughout the year in Thailand rots food quickly. The advantage of household food waste sorting at the source is the most effortless management of food waste in the community. For example, we can divide food waste directly into animal feed such as utilizing fruit and vegetable waste to fish feed, or recooking rice, meat, and inedible meat (bones) into dog feed. In addition, the classification of food at collecting points can be

useful for saving costs and time. In this study, staff estimations show similar results to the direct weight measurement. From this, we concluded that the initiative method of food waste evaluation should be practical and not unnecessarily complicated. In addition, it is challenging to balance between the representative of primary data and the feasibility of data access, the cost, and time make it paramount to develop clear standard guidelines on how to select a representative sample of national statistics for forecasting the national food waste index.

Future studies should investigate the association between cause and reason for food waste generation and suggest proper options to reduce and prevent wasted food. Consumption and wasted food depend on consumer behavior and involve multiple factors. A recent study on food waste was carried out in Malaysia [23], where a survey was used to examine Malaysian wasted food awareness, knowledge, attitudes, and behaviors. In addition, the influence factors of the season and household types on food waste generation rate should be considered. In the summer season and a single-family home was the highest rate of food waste generation [16]. Moreover, WRAP [24] identifies the reason why consumers throw away food that 33 reasons such as buying and making too much food which understanding of food waste in terms of the amount and types of food waste to reduce food and packaging in the household garbage bins. The implemented project in Australia [25] that a paper-based color coding in refrigerators in households, assigning colors to food types (e.g., green to fruit and vegetables, red to meat, etc.) for raising awareness and communication lead to reduce the quantify of available food items in the fridge. In Thailand, the average temperature is high all the year that most affecting wasted food, so improving technology for cooling storage and packaging help to reduce spoil of food.

Conclusions

Overall, in this study, we propose a food waste evaluation method with existing data that is feasible to report the level 1 UNEP food waste index and is more useful for filling data gaps in an inventory than in actual data. In general, official information or Statistics Database sources held by the government is based on reliable research. For this reason, an evaluation method with existing data should be the beginning before moving into more specific measurement methods that establish more reliable monitoring and reporting of national. Nevertheless, this method cannot be used to track progress over time and cannot be used to identify hotspots or causes.

However, direct weighing of waste could give significantly more accurate data to possibly compare at national levels. Estimation of food waste at 2-3 levels allows the total amount of food waste to be classified by sector (households, food service, and retail), material type including edible part (human consumption), and inedible parts (bones, rinds, etc.), and to record the destinations of that food waste. Furthermore, FW accounting by direct measurement should be based on a broad understanding of the context in which the FW is generated, with a constant focus on the aim of the accounting and the classification scheme, must be reasonably easy to understand, for those staff members conducting the analyses. On the other hand, the quantification methodology of measurement should be a combination of methods that gather more comprehensive detailed information in terms of relevance, reliability, level of accuracy, traceability, and comparable to access the physical food waste being quantified. It is important to perform an initial uncertainty analysis to determine the most appropriate representative sample size.

Food waste reduction requires a cooperative effort from all parties across the supply chain, whether it is in raising awareness, policies, and laws, or in the support of operations, or in the management of technological developments. The participation of the public sector has greatly helped to reduce the amount of wastage at the source and tracking and monitoring this progress will aid in the achievement of halving food waste worldwide.

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