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The tree structure — A general framework for food waste quantification in food services

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ABSTRACT

Food waste in the food services industry has been identified as an important unsustainability hotspot, but standardised methods for food waste quantification are lacking. Existing studies on waste quantity assessments have several limitations, such as short and infrequent quantifications times, large methodological variations ranging from physical measurements to visual observations, and lack of comparability across catering unit types. Since lack of comparable waste figures can lead to error-prone analysis, a general framework is needed for waste quantification in food services. This paper presents one such framework that allows data comparisons when overlapping observations are included. The framework was tested in six case studies in professional (public and private) catering units in Sweden. Data were collected from different schools, elderly care homes and hotels and fitted into the framework. The results from these case studies indicate that the framework enables catering units to focus waste quantification on their individual problem areas. It also provides the possibility to extend waste quantification over time without any loss of generalisability. A graphical representation of the framework fits the traditional tree structure and was found to act as a suitable foundation for food waste quantification in food services by structuring collected data. In order to fully utilise the potential of the tree structure, it should be supplemented with precise definitions to create a catering food waste quantification standard.

1. Introduction

Although food waste seems like a simple problem, the solution "to just stop throwing food away" is much more complex. The food waste issue gains in complexity when linked to the three pillars of sustainable development: economic, social and environmental. Although reducing food waste will not automatically result in sustainable development, it can make an important contribution. Food waste is associated with substantial losses of money (FAO, 2013) and natural resources (Steinfeldt et al., 2006; Garnett, 2011; Scholz et al., 2015), but also has moral implications in relation to food security (Stuart, 2009; Godfray et al., 2010; FAO, 2012). In recent times, industry (Tesco, 2014), governments (Rutten et al., 2013) and international organisations (UN, 2016) have initiated waste reduction programmes. Reducing food waste is also less controversial than, for instance, reducing meat consumption or increasing productivity by expanding the use of genetically modified organisms. Since food is wasted for a large number of reasons and by different actors in the food supply chain, it is difficult to find a 'quick fix' solution. Food can also be wasted as a result of measures to increase profits or protect public health. In many countries, food waste creates a problem if it is landfilled or left in illegal dumping sites. In other countries, Sweden included, landfilling of organic waste is prohibited (Ministry of the Environment and Energy, 2001) and surplus food is considered a resource that can be used for biogas production or for feeding people in need (Eriksson et al., 2015; Eriksson and Spångberg, 2017). It is therefore not the wasted food that is the prime concern, but the wasteful behaviour that results in unnecessary food production in the first place.

Before food wastage can be reduced, it is necessary to identify the quantities of waste generated. This requires accurate waste estimation (Eriksson, 2012, 2015) and is an essential first step in evaluating the effect of any food waste reduction measure. However, international

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studies of food waste in food services lack accurate data. One survey showed that only about half of Swedish schools measure food waste at a frequency of one week per semester or higher (School Food Sweden, 2013). In studies in the UK, food waste was quantified for two days in three hospitals (Sonnino and McWilliam, 2011) and for 28 days in one hospital (Barton et al., 2000); in studies in Sweden for two days in four kitchens (Engström and Carlsson-Kanyama, 2004); in Switzerland for five days in two kitchens (Betz et al., 2015); in Portugal for 471 school meals during one month (Martins et al., 2014); in the United States for five days in one kitchen (Byker et al., 2014); and in Finland for one week in 55 kitchens (Katajajuuri et al., 2014). Such small-scale measurements may produce results that are inconclusive and biased, making any interpretation error-prone.

Moreover, the method used for quantifying food waste and the scope of previous studies vary. Some studies are based on visual observations (e.g. Connors and Rozell, 2004; Hanks et al., 2014), while others use physical measurements. Engström and Carlsson-Kanyama (2004), in their study of two school kitchens and two restaurants, categorised food waste into storage losses, preparation losses, serving losses, plate waste and leftovers. All the losses were then divided into food item types. Betz et al. (2015) followed broadly Engström and Carlsson-Kanyama's method, with the addition of making a distinction between gross and net weight. In Sonnino and McWilliam's (2011) study of food waste in hospitals, all food, containers and plates were weighed before and after meals to calculate the waste. One meal was studied in great detail, while all leftover individual food items on the plate were separated, grouped and weighed. A similar approach was used by Martins et al. (2014) in their study of plate waste in Portuguese primary schools, i.e. the plates were weighed before and after the meal. Barton et al. (2000) studied a hospital's plate and tray waste by measuring all food supplied and wasted during a 28-day period and weighing the total remaining food at the end of each meal. Each food item was also weighed separately. Food waste was calculated as the difference between food served and food recovered at the final weighing. Byker et al. (2014) studied food waste in a school where, after the students had completed their meal, the research team collected lunch trays and separated food and beverages into respective bins, which were weighed on a digital scale. In a study by Katajajuuri et al. (2014) of waste in the Finnish food sector, the waste generated during cooking and serving and leftovers from the customers were weighed and noted. Hackes et al. (1997) studied food waste in the American elderly sector by collecting and measuring all uneaten food items from the residents in a retirement community after each meal over seven days. The weight and the volume of the waste were computed on a per meal, per day and per week basis. A similar study of plate waste was conducted by Hayes and Kendrick (1995) at five American elderly catering centres, where waste was collected from the plates and separated by menu item. The percentage of food waste was calculated, using serving size to determine total mass of food served.

There is clearly a need for a more general framework that enables comparisons of food waste quantifications. For instance, in some studies, quantification of food waste is an essential element (e.g. Kallbekken and Sælen, 2013) but the methods used are not described. In the majority of the studies cited above, the measurements were time-consuming and almost exclusively performed by researchers. In order to get actors in the food service sector to conduct measurements *themselves,* the method must be time-efficient in terms of learning and preparation and implementation. The idea of a *framework* derives from the belief that quantification can be performed more easily. Measurement of food waste in supermarkets represents a good example, where large-scale studies have been conducted using high-precision data collected by the supermarkets themselves (e.g. Eriksson et al., 2012, 2014, 2015, 2016a,b, 2017b; Lebersorger and Schneider, 2014; Brancoli et al., 2017).

Against this background, the aim of the present study was to develop and test a methodological framework for food waste quantification in food services that could demonstrate the complex nature of food waste, while increasing the transparency of quantification methods. The framework developed was applied to a set of case studies, where data were fitted to test the generalisability. The framework was developed with the focus on Swedish food services, but the general structure should also be applicable in other countries and sectors. The framework is described in Section 2 of the paper, while the cases and the results from case analyses are presented and discussed in Section 3. Section 4 presents some conclusions from the work.

2. Materials and methods

The first step was to develop a general framework for food waste quantification in food services. The next step was to apply the framework to several case studies providing actual food waste data from different food service organisations. This might seem like a linear process (cf. Papargyropoulou et al., 2016), but in reality the development process involved several cycles of testing and redeveloping.

2.1. Context and rationale

In the Swedish food services sector (including both public and private catering units), environmental issues related to food waste are a growing concern. This could be due to the high levels of food waste in Sweden. According to the Swedish Environmental Protection Agency (SEPA, 2016), 70 000 t of food waste are generated every year in the Swedish public food service sector, including schools, pre-schools, elderly care homes, hospitals and prisons. The amount generated by private restaurants is similar, 66 000 t per year. This is much lower than the corresponding estimate for Swedish households (700 000 t per year), but since households serve a much larger volume of food, comparisons of absolute values give a limited view of the problem and therefore relative waste values should be considered. According to a recent study by Eriksson et al. (2017a), relative waste in 30 kitchens in the Swedish municipality of Sala was 75 g per portion served, or 23% of the mass of food served. Other studies of relative waste levels in similar types of catering establishments indicate what could be considered a normal level, although the studies differ in scope and refer to different times and geographical places. The four restaurants in Stockholm investigated by Engström and Carlsson-Kanyama (2004) wasted on average 20% of delivered mass, corresponding to 92 g per portion served, and the two kitchens in Switzerland investigated by Betz et al. (2015) wasted 10.7% and 7.7%, corresponding to 91 and 86 g per portion served.

In the absence of simpler methodology, Jacko et al. (2007) argue that aggregated methods to measure plate waste (e.g. weighing bins of collected waste) are more accurate than selective methods (e.g. weighing each plate/tray separately), as they are less time-consuming and hence more suitable for long-term data collection performed by kitchen staff. However, there are obvious advantages of achieving the higher resolution in data that selective methods can provide, e.g. they can enable investigation of factors actually causing food waste (as done by Steen, 2017). Such studies are very few in number, perhaps because of the lack of a common standard for quantifying and reporting food waste. This makes results from different organisations difficult to compare. The WRI's Food Loss and Waste Accounting and Reporting Standard (World Reasource Institute, 2016) could be used, but it is possibly too general to exactly identify a reasonable trade-off between 'resources used' for waste quantification and food production. Although food services can, in theory, follow the WRI approach, the data are generally not comparable across organisations, unless some more detailed methodology is applied. In this context, we attempted to develop a more generalisable quantification framework, as is described in the ensuing sub-sections.