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The challenge of characterising food waste at a national level—An Australian example

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ABSTRACT

This study critiques available methods for the national-level, sector specific, characterisation of food waste. Such estimates are required to account for the environmental and socio-economic implications of food waste, and to identify the highest impact and most cost-effective solutions to reduce those negative outcomes associated with wasted food. Australian results are compared using three fundamentally different approaches taken from the literature, along with two variants implemented for this study. The results are extremely inconsistent, suggesting that our current quantitative knowledge on Australian food waste may not be sufficient for optimal prioritisation of mitigation options. While these 'conventional' methodologies may not be sufficient in isolation, their strengths are complementary and would ideally be integrated into a single analytical framework that incorporates the best available top-down and bottom-up datasets.

1. Introduction

While campaigns to reduce food wastage have achieved a very high public profile (e.g. Victoria State Government, 2016; WRAP, 2016), there is surprisingly little information available on either the quantities of food wasted nor its consequences (Parfitt et al., 2010; Thyberg et al., 2015). Despite that limitation, those top-down campaigns are a response to growing concerns about the high levels of wastage in food systems, the expectation of substantial growth in future global food demand, and the strong association between agricultural production and environmental impacts (FAO, 2014, 2013).

A lack of detailed knowledge on food wastage could constrain the effectiveness of those campaigns in various ways. Firstly, without a detailed understanding of how much wastage is currently occurring, we do not have meaningful baselines against which the effectiveness of food waste mitigation efforts can be measured. Secondly, proper characterisation is needed to assess the economic and environmental implication of food waste. Thirdly, it limits our ability to target food waste campaigns to specific food types, or to specific participants in the food supply chain. Targeted campaigns will be critical to achieve effective outcomes, as the diverse range of opportunities to reduce food waste could deliver very different environmental and economic outcomes (Beretta et al., 2013). Both the environmental burdens of wasted food, and the potential for socio-economic barriers to limit the effectiveness of waste reduction measures, can vary substantially across different food categories, and across diverse points in the food supply chain (Reutter et al., 2017). These differences arise because of the huge variation in the way that different foods are produced, stored, packaged, distributed and prepared. Hence, for example, the environmental significance of wasting meat is different to that of wasting fruit (Vanham et al., 2015); and the socio-economic implications of wasting usable food on the farm can have different implications than those associated with food wastage in households (Reutter et al., 2017).

Food waste characterisation at the national level remains relatively poorly understood (Buzby and Hyman, 2012; Xue et al., 2017), with much of the national level food waste critique provided both by the scientific (e.g. Brautigam et al., 2014; Kummu et al., 2012; Oelofse and Nahman, 2013) and non-scientific communities being heavily reliant on the results from a single global study undertaken by the FAO (Gustavsson et al., 2011). Relatively little attention is paid to the concerns, raised in that FAO study itself, that their results should be interpreted with great caution due to a lack of data for many countries and for stages of the food supply chain. The only study to compare food waste estimates at a country level shows that the results can vary significantly depending on the assumptions used (Brautigam et al., 2014). The substantial gaps in the available information, the reliance on outdated data, and inconsistencies in the scope and methods employed by studies, mean it will be difficult to compare and benchmark results

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across regions and time frames (Brautigam et al., 2014; Thyberg et al., 2015).

Furthermore, we are not aware of any evaluation being undertaken into the methodological validity across the range of studies that exist. While there has been a heavy reliance on the top-down FAO study (Gustavsson et al., 2013, 2011), a high degree of attention has also been paid to the results of bottom-up approaches reliant on the sampling of waste streams or interviews (NSW Environment Protection Authority, 2016; WRAP, 2016). Those results are often used to guide policy thinking, yet no-one has compared whether or not they are consistent with the top-down estimates frequently adopted from the Gustavsson et al. (2011) study. More recently, a third approach has been proposed by Reynolds (2013), disaggregating estimates of overall food waste in the economy using the supply chain linkages and household expenditure data that are embedded in monetary input-output tables (MIOT). While that approach has some obvious appeal in countries where MIOT are compiled by statistical agencies, it does rely on an allocation of overall food wastage in proportion to food flows measured in monetary terms. Given that monetary allocation can be problematic for products (such as food) that vary greatly in price per unit mass (Schaffartzik et al., 2015), further critique of that approach is warranted.

This study provides the first direct comparison of the results obtained using these three different approaches from the literature, along with two new variants chosen to avoid the monetary allocation concerns with the MIOT technique: (i) a version of the MIOT expressed in physical units, so as to consider the effect of monetary allocation on supply chain waste estimates; and (ii) using bin-audit data to disaggregate the estimate for total household waste. An Australian case study is used to critique these methods, in terms of their capacity to characterise food waste at a national-scale, for different supply chain steps and different food types. Our critique primarily focusses on the data scope and data quality employed by the different methods, their potential effect on the results, and the level of sectoral and food detail in the analysis they can provide.

2. Background

This section provides an analysis of literature that has characterised food waste at the national level, differentiating by food waste producer and the food category that is being wasted (see Table 1).

Our review suggests that challenges in interpreting the limited available data on food waste will be compounded by difficulties in comparing results across the few studies available. The available literature sources lack consistency in study scope, in the definitions used, and in the way that results are reported. To overcome these difficulties, the World Resource Institute (2016) has recently developed the Food Loss and Waste Protocol, which advocates for the use of a common definition of terms and clearly defined research scopes.

In this paper, we adopt the Food Loss and Waste Protocol definitions of *food category* and *material type,* and propose the identification of *level of food transformation*. *Food category* refers to the type of food being wasted (e.g. wheat vs. bananas). *Material type* describes the potential usability of the wasted products: edible or inedible parts of food (e.g. the banana flesh vs. the banana peel). *Level of food transformation* describes how food waste is being reported. It could be described as primary product equivalents (e.g. for pasta reported as flour, egg, salt) or in food products.

2.1. Spatial coverage

Given the expectation of substantial change in the future global food system (Godfray et al., 2010), the patchy coverage of existing studies will be insufficient to predict the future evolution of food wastage and to identify opportunities to mitigate that wastage. Only two of the eight national studies address developing countries (Liu et al., 2013; Oelofse

Table 1
Country level studies on food waste characterisation. Only two studies have been conducted on a developing country. Most studies utilise the "disaggregation of total available food" as their main method and provide little disaggregation on food categories. Numbers in parenthesis provide the level of disaggregation found in each of the characteristics.

Publication	Geographic scope	Data year	Food categories	Material type	Level of transformation	Producer	Method
Kantor et al. (1997)	USA	1995	All categories (260)	Edible parts (2)	Primary product equivalent	Retail, foodservice, and consumer level (3)	Disaggregation of total available food.
Beretta et al. (2013)	Switzerland	Various	All categories (22)	Edible and inedible parts (3)	Primary product equivalent	Whole food supply chain (6)	Disaggregation of total available food.
Gustavsson et al. (2011)	Global (6 regions)	Various	All categories (7)	Edible parts (2)	Primary product equivalent	Whole food supply chain (5)	Disaggregation of total available food
Vanham et al. (2015)	EU (1)	Various	All categories (17)	Edible and inedible parts (2)	Primary product equivalent	Household level	Disaggregation of total available food
Oelofse and Nahman (2013)	South Africa	Various	All categories (7)	Edible parts (2)	Primary product equivalent	Whole food supply chain (5)	Disaggregation of total available food. Based on Gustavsson et al. (2011)
Liu et al. (2013)	China	Various	Vegetal foods (3)	Edible and inedible parts (1)	Primary product equivalent	Whole food supply chain (5)	Disaggregation of total available food. Based on Gustavsson et al. (2011)
Brautigam et al. (2014)	EU (27)	2006	All categories (7)	Edible parts (2)	Primary product equivalent	Whole food supply chain (5)	Disaggregation of total available food. Based on Gustavsson et al. (2011)
Kummu et al. (2012)	Global (Country level)	2005–06	Vegetal foods (44)	Edible parts (2)	Primary product equivalent	Whole food supply chain (5)	Disaggregation of total available food. Based on Gustavsson et al. (2011)
Reynolds (2013)	Australia	2008	All categories (61)	Edible and inedible parts (1)	Final product	Whole food supply chain (345)	Disaggregation of total food waste. Recently proposed method using economic indicators.
Reynolds et al. (2016)	Nez Zealand	2011	All categories (14)	Edible and inedible parts (1)	Final product	Whole food supply chain (126)	Disaggregation of total food waste. Recently proposed method using economic indicators.
Katajajuuri et al. (2014)	Finland	2010	All categories (9)	Edible parts	Final product	Retail, meal providers and households (9)	Extrapolation of sample data.