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Assessing food losses and waste with a methodological framework: Insights from a case study

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ABSTRACT

Despite growing concerns about food losses and waste (FLW), research that focuses on FLW, especially along food supply chains (FSC), frequently uses unsatisfactory methodology and fails to provide clear results. The article reviews the existing methodological gaps with the aim of proposing a methodological framework for assessing and reporting FLW. The methodological framework was applied to a case study conducted on the "traditional" tomato supply chain in Cali (Colombia) from a waste management perspective. Interviews and surveys were carried out with farmers, traders (wholesalers, middlemen) and corner stores. The quantitative levels of FLW are presented. Empirical results show that unsold tomatoes are frequently used for different purposes. The quantity or rate of FLW alone may not be sufficient to justify the research interest and guide policy intervention: data may conceal more important issues, such as questions of food safety and health risks or economic losses. From a methodological perspective, it would be interesting to test the applicability of the framework to other aspects of FLW (e.g. qualitative FLW) and to wider case studies (e.g. households).

1. Introduction

In recent years, several reports and publications have presented estimations of FLW in order to highlight the importance of the issue. FAO estimates that one third of food produced in the world for human consumption is lost or wasted along food supply chains (FSC) (Gustavsson et al., 2011). Other reports claim that FLW are in the order of 50% of production (Lundqvist et al., 2008). Figures ranging from 10 to 40% and as high as 50–70% are also regularly quoted (Affognon et al., 2015). The scale of FLW reported varies greatly. The differences can be explained by the diverse commodities, the geographical region or the scale taken into account, the season and the stage of the targeted FSC (Tyler, 1982). The definition and methodology used to assess FLW, as well as how data is processed and presented, are also significant factors when it comes to explaining data discrepancies.

Despite the growing concern on FLW issues, research that focuses on FLW frequently uses unsatisfactory methodology and fails to provide clear results (Sheahan and Barrett, 2016). Details on how FLW have been calculated and where unsold food products actually end up are rarely available (e.g. garbage, home-consumption, food donation, etc.) (Cardoen et al., 2015). Research on FLW along food value chains, from production to retail, still uncommon (Minten et al., 2016; Parfitt et al., 2010; Redlingshöfer et al., 2015). Knowledge gaps exist in different regions and for different commodities. For example, there is little available data on the post-harvest losses of fruit and vegetables in developing countries, especially in Latin America (Kitinoja and Kader, 2015). Fruit and vegetables have historically been neglected despite the fact that they constitute an important part of daily food consumption and are essential for health and nutrition (Affognon et al., 2015; Weinberger et al., 2008). The fragility and high moisture content of some fruit and vegetables make handling, transportation and marketing a challenge, especially in the tropics (Addo et al., 2015; Aidoo et al., 2014).

Knowledge and methodological gaps on the quantities of FLW are still the major obstacles to any progress in this area (Affognon et al., 2015). Consequently, it is difficult to target, prioritise and design actions to prevent and reduce FLW (Thyberg and Tonjes, 2016). Quantifying FLW is, therefore, recognised as a necessary step to identifying how much, why and where FLW occur (Fusions, 2014). Improving FLW assessment methodologies has been recognised as essential for overcoming the methodological weaknesses and to increase transparency (Fusions, 2014; Priefer et al., 2016; Timmermans et al., 2014).

This study sets out to fill some of the gaps and to present some of the advantages of a suitable methodological framework. First, a methodological framework for the assessment and report of FLW is proposed. It is based on the identification of the methodological errors and deficiencies that are found in the literature. The article attempts to make a positive contribution to the existing studies in this area (FAO, 2016; Hanson et al., 2016; Liu, 2016; Redlingshöfer, 2015). The recent agreement on the protocol for measuring FLW (Hanson et al., 2016; Tostivint et al., 2016) will help to put our methodological framework into perspective in the final

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discussion. Second, a case study is used to illustrate the relevance of the methodological framework. Third, where knowledge gaps exist, data and empirical findings are generated and provided, respectively (e.g. Latin America, fruit and vegetables, food supply chain, etc.). The levels of FLW along the "traditional" tomato value chain that supplies the city of Cali in Colombia are presented. Detailed information on the different destinations of unsold products is provided.

In Section 2, the methodological weaknesses are identified in order to improve how FLW are assessed and reported. As a result, Section 3 presents a methodological framework. Section 4 uses a case study to illustrate how the methodological framework should be applied. Section 5 reports and discusses the empirical findings with regard to the levels of FLW along the "traditional" tomato supply chain in Cali. Section 6 presents the conclusions.

2. Background: the methodological gaps

Paradoxically, although references to different percentages of FLW are common, there are few research studies on FLW assessment available on scientific databases (Science Direct, Web of Science, Jstore, etc.). This raises the following questions: where do figures on FLW come from? What do FLW percentages represent?

2.1. Unreliable data

Some figures are simply based on the authors' own estimates of FLW. For example, Kader (2005) evaluates that one third of all fruit and vegetables produced are never consumed. This figure is frequently quoted (e.g. 216 citations registered on Google Scholar), although the estimate is partly based on the author's own experience. This also shows that many studies (Lundqvist et al., 2008; Parfitt et al., 2010) refer to estimations published by other authors. However, most of the research on post-harvest losses was conducted in the 70′s and 80′s. Consequently, the sources are often untraceable or linked to old datasets (Affognon et al., 2015).

Other authors use existing data (Buzby and Hyman, 2012; Kummu et al., 2012; Lipinski et al., 2013; Monier et al., 2010; Nahman and de Lange, 2013; Venkat, 2011) in order to simplify the task of quantifying FLW. Here, the same problem occurs. The methods used to determine FLW from databases (e.g. Eurostat, FAO data, USDA) are not always robust. The resulting data may be fragmentary or heterogenic. For example, FAO's report (Gustavsson et al., 2011) is based on old results from the literature, combinations of data from different sources, individual assumptions and other FAO statistics. Data reported is not homogenous, robust or even up to date. However, one of the most frequently quoted figures is that one third of global human food production is lost or wasted (Gustavsson et al., 2011).

Percentages of FLW quoted and referenced remain largely unquestioned despite the fact that they are often derived from grey literature and unpublished works. Some studies have been collecting their own data. However, little is known about the methodologies used for FLW assessment (Affognon et al., 2015).

2.2. The ambiguous nature of FLW

The absence or vagueness of definitions of FLW constitutes a recurring methodological error. When the definition for FLW is not specified or it is not sufficiently accurate (Abass et al., 2014; Addo et al., 2015; Aidoo et al., 2014; Ramchandra et al., 2015; Sharma and Singh, 2011), it is difficult for the reader to determine what is considered as FLW in the assessment. For example, Majumder et al. (2016) specify that post-harvest losses were estimated as the sum of all mass loss that occurred in post-harvest operations, excluding the loss of dry matter. However, there is no explanation about how farmers were asked to report the sizable losses in the survey (e.g. is it the mass difference before and after each post-harvest operation? Or is it the difference between the quantity harvested and the quantity sold? Are FLW amounts weighted or declared?). Other studies fail to define quantitative losses precisely (Kaminski and Christiaensen, 2014; Kumar et al., 2006; Minten et al., 2016) in relation to the final use of the food product (e.g. do they refer to products that are unsold regardless of their final destination? Or do they just refer to the products that are discarded, excluding food products that are unsold but used for a different purpose?).

When studies report quantitative loss, it is unclear whether qualitative losses or economic losses have been inadvertently included in the calculation. For example, Kaminski and Christiaensen (2014) report quantitative losses when farmers are asked the question "did you incur any post-harvest loss (PHL) due to rodents, pests, insects, flooding, rotting, theft, and other reasons?" or "what was the proportion lost?" The definition of "loss"' is unclear and the questions are worded in such a way that farmers' responses are unlikely to be homogenous. Some farmers will report quantities that were not sold at the initial target price as being an economic loss. Others will refer to all the quantities that are unsold (regardless of their final destination). Some will only answer questions about the quantities of maize discarded and not the amount used for other purposes (e.g. animal feed or home-consumption).

Inconsistency between the definition adopted and the FLW indicator chosen is another methodological error. Weinberger et al. (2008) consider loss as all food products unfit for human consumption, which excludes lower quality food products that are still saleable. For middlemen and retailers, losses are measured as the difference between the quantity purchased and the quantity sold. This measure is slightly different from the definition adopted. Firstly, unsold products can be donated or used for home-consumption if they are still fit for human consumption. Food donation and home-consumption are considered as losses despite the fact that they are not included in the definition chosen for FLW. Secondly, the perception that different stakeholders have of poor quality and what is considered saleable may vary. It depends on what the consumer will accept and on the marketing strategy used by each retailer. The measure is not likely to be homogenous among stakeholders. Thirdly, not all food products sold are destined for human consumption. Some commodities (e.g. wheat or other cereals) are geared to secondary markets, especially when they are poor quality (e.g. animal feed). In this case, products should not be counted as losses although the definition does consider them to be a loss.

Experts in charge of measuring FLW may have different perceptions of what is considered FLW compared to FSC stakeholders who report losses, leading to assessment bias. According to the definition adopted, the stakeholders should be asked detailed questions about the quantities lost in order to avoid any *quid pro quo*, assessment bias and inconsistencies. Data collectors have to be clear about the definition adopted when results are reported. Furthermore, how figures for FLW are presented is extremely important to avoid problems with the interpretation and manipulation of data.

2.3. Lack of transparency

Average percentages for FLW are often presented as being the main results. Average percentages of FLW are difficult to interpret without their respective standard deviations, minimum and maximum percentage intervals, percentiles or medians. Average figures are statistically sensitive to extreme values and may be misleading, especially in developing countries where extreme values of FLW are not uncommon. For example, while many stakeholders may have a very low rate of FLW, the average figure could be surprisingly high if some stakeholders register extremely high values. In this case, the average percentage (alone) could be misleading and generate an overestimation of FLW. Moreover, it could wrongly suggest that FLW are a widespread problem among stakeholders, while in reality that may not the case.

The way estimates are presented can also be confusing. Results will vary depending on whether range of losses, total loss or cumulative losses are presented (Kitinoja and Kader, 2015). Miscalculations can also be found in the literature. Sometimes average percentages of FLW are added along food value chains (Kumar et al., 2016; Majumder et al.,