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Opening the black box of food waste reduction

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ABSTRACT

Surplus food management plays a key role in food waste reduction. This paper addresses the multifaceted concept of food supply chain sustainability by presenting a model of surplus food generation and management (called ASRW, Availability-Surplus-Recoverability-Waste), which encompasses the integrated food supply chain (i.e. business, environmental and social players). The model was developed using a bottom-up approach, by conducting 30 exploratory case studies and iterating theory development and data analysis. Three confirmatory case studies, from different food supply chain stages, are also presented to demonstrate how the model can be used to identify food waste reduction strategies.

Introduction

This paper presents the development of a bottom-up model of surplus food generation and management by combining conceptual arguments with an empirical analysis of the food supply chain. The objective was to devise a methodology that can be used to understand and quantify surplus food, "recoverable" surplus food and food waste, at company, sector and country levels.

There are several issues related to food waste, food security and the management of surplus food that have created a need for research in this area. Food waste is acknowledged to be a huge problem worldwide, even though the definition of various terms and information collection processes are not yet well harmonized. Gustavsson et al. (2011) estimated that food wastage is particularly severe in developed countries, with estimates as high as 280–300 kg per capita per year in Europe and North America. In the United States, food waste and losses at the retail and consumer levels were found to amount to 188 kg per capita per year, or an overall value of 165.6 billion dollars (Buzby and Hyman, 2012). Countries in the European Union (EU) are reported to generate 179 kg per capita of food waste every year, exclusive of agricultural waste (O'Connor, 2013). The picture, though patchy, is at variance with the available data on food security, even in developed regions (see section 'Literature review'). In 2011, 5.7% of American households experienced a disruption to their normal eating patterns due to limited resources (Coleman-Jensen et al., 2012), and 8.8% of EU inhabitants suffered severe material deprivations, which in many cases entailed insufficient protein in the diet (Eurostat, 2013). The incongruity between food waste and food security data is a strong indicator that an integrated approach to these two issues could be of significant value.

Surplus food management is increasingly acknowledged to be a lever for the mitigation of food insecurity, especially in developed countries. Both surplus food reduction at the source and its recovery for human consumption are critical elements in the global food security effort, along with the growth of agricultural productivity, the evolution of dietary habits (especially in developed countries) and the enhancement of food-chain infrastructure (especially in developing countries). Surplus food can be recovered and donated to help those in need (Kantor et al., 1997; Tarasuk and Eakin, 2003; Parfitt et al., 2010; Gentilini, 2013; Garnett, 2013), or can be reduced at the source for a more efficient use of input resources (Cuéllar and Webber, 2010; Buzby et al., 2011; Buzby and Hyman, 2012). At the same time, reducing food waste is, per se, an important part of the effort to attain environmental goals. In fact, both source reduction and recovery are high-priority strategies in the food waste hierarchy (EPA, 2006).

Finally, the research presented in this paper was motivated by the belief that a bottom-up approach is needed to understand and model surplus food generation and management throughout the food supply chain, and to obtain sound empirical information. Until several years ago, there were relatively few analytical and empirical studies on sustainable food management, and some methodological concerns were raised in relation to these studies (see section 'Literature review'). More recently, there have been quite a few in-depth studies that have addressed this issue in

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developed countries (e.g. Griffin et al., 2009; Mena et al., 2011; Sonnino and McWilliam, 2011; Buzby and Hyman, 2012; Beretta et al., 2013). The literature in this emerging field of research has provided two much needed additions to the pre-existing research: the scope of the analysis has now been explicitly defined (e.g. food waste is distinguished from food scraps), and it has been made evident that generalizations cannot be made. There is, in fact, considerable variability between available estimates of food waste and losses due to differences in geographic setting, sample size, and supply chain stage considered.

Suggestions from recent studies have been incorporated in the work presented in this paper. Accordingly, a micro-level perspective has been assumed, i.e. individual players (e.g. farmers, manufacturers, retailers) have been analysed, and an empirically-based methodology for analysing the food supply chain has been proposed. Current ideas presented in the literature are encompassed in the conceptualisation of surplus food management and recovery proposed here. The focus is on two key concepts: "Surplus Food", i.e. the edible food that is produced, manufactured, retailed or served but for various reasons is not sold to or consumed by the intended customer; and "Food Waste", i.e. the surplus food that is not recovered to feed people, to feed animals, to produce new products (e.g. jams or juices), new materials (e.g. fertilizers) or energy.

This paper also makes two original contributions to this developing field of research: it presents a unified conceptual model that can support the analysis of both the supply chain as a whole and its individual stages, and, coherently with the bottom-up vision, the conceptual model has been customised within the different stages of the food supply chain, i.e. agriculture and fishing, manufacturing, retail trade, food service and household consumption.

There are a number of reasons why the proposed methodology can be a useful tool. The unified model provides policy-makers and managers with a common language, i.e. clear-cut concepts and keywords that can be used at a company, sector or country levels. Customisation of the model to describe the different supply chain segments provides a means of differentiating surplus food and food waste generated by different companies and sectors based on the "degree of recoverability". This information, in turn, is essential if policy-makers are to determine targets that are challenging yet attainable, and to prioritize recovery efforts. Finally, this methodology can be used to monitor and quantify surplus food and food waste. This is necessary if managers are to be able to implement strategies that are coherent with the food waste hierarchy, and for policymakers to design bottom-up quantitative assessment plans.

The remainder of the paper is organized as follows. The main contributions to the literature on surplus food management are discussed in section 'Literature review'. The research framework in terms of objectives and methodology is presented in section 'Research framework'. In section 'ASRW model: conceptualisation' a conceptual model for assessing surplus food and food waste is proposed. In section 'ASRW model: refinement and customisation' the model is customised across supply chain stages. Finally, in section 'ASRW model implementation' the model is applied to three case studies. Conclusions and suggestions for further research are proposed in the final section.

Literature review

This section presents a review of the extant research on the generation and management of surplus food and food waste. The literature was reviewed according to five perspectives: relevance of the issue; scope of existing analyses; methodologies used to assess the phenomenon; quantitative estimates of surplus food; strategies and policies for managing surplus food.

Food security and the relevance of surplus food management

The FAO (United Nations' Food and Agriculture Organization) stated in 1996 that "food security" exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (Pinstrup-Andersen, 2009).[3] This definition highlights the two main aspects of food insecurity and poverty: (i) food availability and access (Pinstrup-Andersen, 2009), and (ii) food safety, i.e. safe and healthy food, in contrast to eating issues such as obesity and malnutrition (Aiking and De Boer, 2004). Over 820 million undernourished people live in developing countries, but food security is also an issue in developed regions, where 15.7 million people are undernourished (FAO, 2013).

A multifaceted and coherent global strategy is needed to address the food security challenge (Godfray and Charles, 2010), especially as the world population is projected to reach 9.6 billion in 2050. As in the past, an environmentally sustainable increase in agricultural productivity is crucial to solving the problem of feeding the world over the long term (Beddington, 2010; OECD, 2013). Another element is related to dietary changes, particularly to a reduction of meat fractions in both emerging and rich countries (Godfray and Charles, 2010). Finally, food security is also dependent on the management of food waste (Kantor et al., 1997).

Gustavsson et al. (2011) estimated that global food losses and waste throughout the food supply chain have reached 1.3 billion tonnes per year, i.e. one-third of global food production. However, different strategies are needed to tackle the food waste issue in developing and developed countries. In the developing world, food losses are mainly attributable to the absence of food-chain infrastructure and a lack of knowledge or investment in technologies (Godfray and Charles, 2010). The issues are different in developed countries, where surplus food generation plays a prominent role (e.g. overstocking or preparing too much food due to difficulties in predicting the number of customers) (Buzby and Hyman, 2012).

Therefore, when focusing on developed countries, surplus food management is a key element of the food security issue. The recovery of surplus food is a way of providing food to those who need it (Parfitt et al., 2010). Its reduction at the source can free up valuable resources that can be better used to respond to the food security challenge. Indeed, as highlighted by Buzby et al. (2011), Buzby and Hyman (2012), food waste represents a significant amount of economic resources consumed throughout the food lifecycle (production, warehousing, transportation). Engström and Carlsson-Kanyama (2004) estimated food losses to be 287 million portions each year at food service institutions in Sweden, corresponding to a monetary value of just under 1 billion euros. Cuéllar and Webber (2010) estimated that the energy embedded in wasted food represents approximately 2% of annual energy consumption in the United States. Moreover, food production causes negative impacts on the environment, mainly in terms of greenhouse gas emissions (Levis et al., 2010), water consumption (Darlington and Rahimifard, 2006), pollution (Garnett, 2013) and decreased biodiversity (Engström and Carlsson-Kanyama, 2004).

As discussed in the introduction, the responsible management of surplus food can represent part of the solution to food security and environmental challenges, namely the need to feed more people while making the food value chain more environmentally sustainable and resilient (Garnett, 2013).

[3] Food poverty entails an only slightly different definition, i.e. the situation whereby a person does not have reasonable access to food that would provide a healthy diet, because of insufficient income, or unreasonable difficulties of distance, transport or similar, or inadequate information (Alexander and Smajne, 2008).