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The implications of food waste generation on climate change: The case of Greece

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ABSTRACT

Food waste is becoming an increasingly significant global issue due to its economic, social and environmental implications. In addition, food waste relates to climate change since food originates from agriculture and ends up as waste while energy is consumed during its life cycle stages. The aim of this paper is the estimation of the GHG emissions associated with food waste generation in Greece. The scope of the research includes both the emissions associated with the production of food and those associated with the management of food waste. In order to assess the food waste generation from Greek households a field research with the use of food waste diaries was conducted. Based on the aforementioned measurement, the FAO food balance sheet of Greece for 2009, and relevant GHG emissions data found in international databases and literature sources, an estimation of the GHG emissions associated with food waste in Greece has been conducted. The results indicate that approximately 100 kg of food waste per person are generated annually, of which approximately 30 kg per person are avoidable. Moreover, the calculations of the present research reveal that emissions of 5672.5 Gg of CO_2 eq. are associated with food waste in Greece.

Keywords: Prevention; Food waste; Greenhouse gases; Mitigation; Greece

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1. Introduction

There is strong evidence that the most environmentally damaging form of human consumption is eating (Ehrlich, 2011). For instance, Tukker et al. (2011) estimated that 27% of the environmental impacts of European total consumption are related to food consumption. On the same time, there is a rising demand for food, driven by two factors: (i) the continuing increase of the world population, (ii) the increasing global affluence coupled with a desire to eat animal products (Parry and Hawkesford, 2010; Tukker et al., 2011). However, it is widely acknowledged that food production faces serious pressures due to climate change, among other factors (Parry and Hawkesford, 2010). More specifically, the production of food is affected by climate change, due to its impacts on a multitude of key agricultural factors (Smith et al., 2007); on the other hand, food choices and proper food management can also have positive impacts on the mitigation of climate change (Carlsson-Kanyama, 1998; Geeraert, 2013). Following the pioneering work by Carlsson-Kanyama (1998) much of the debate has focused on the contribution that food and dietary choices make to global warming (Saxe et al., 2013; Wallén et al., 2004),

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as the emissions of the major gases that contribute to the greenhouse effect are closely related with food production and consumption (Carlsson-Kanyama, 1998). Additionally, as the demand for food increases, so does the amount of – perfectly suitable for human consumption – food that it is wasted. Recently, the Food and Agricultural Organization (FAO) estimated that approximately a staggering one third of food produced for human consumption is either lost or wasted through the food supply chain, from agricultural production and post-harvest handling and storage, to processing, transportation, distribution and consumption (FAO, 2014b).

1.1. *Food waste generation*

Food waste is an increasingly important topic of interest due to the ethical, financial and environmental implications that it relates to (European Commission, 2010; FAO, 2014b). Food waste is "*composed of raw or cooked food materials and includes food loss, before, during or after meal preparation in the household, as well as food discarded in the process of manufacturing, distribution, retail and food service activities*" (European Commission, 2010). Thus, food waste is generated throughout the life cycle of food. From an environmental standpoint of view, food waste is a waste of valuable resources with obvious environmental implications, as significant resources are required for food production, manufacturing, transportation, storage, retailing and preparation (European Commission, 2010; FAO, 2014b; WRAP, 2009).

Regarding the causes underlining the dynamics of food waste generation, they seem to be sector and country specific (European Commission, 2010; FAO, 2014b). In affluent economies, such as those in industrialized countries, post-consumer food waste accounts for the greatest part of the losses and most of the avoidable food waste fraction is derived from private households (Parfitt et al., 2010; Koivupuro et al., 2012). These statements are supported by a preparatory study for food waste generation in the EU-27, which reports that households produce 42% of the total amount, followed by the manufacturing sector with 39%. The food service–catering sector generates 14% and the retail–wholesale sector produces the remaining 5% (European Commission, 2010).

Moving on to the actual figures reported for food waste by notable international organizations, the FAO of the United Nations estimated that the per capita food waste generation in Europe and North-America is 95–115 kg/year (FAO, 2014b). The European Commission reports an even higher value of 179 kg/person/year as the average total amount of food waste generated in the EU27 (European Commission, 2010). However, specific data referring to countries, even the developed ones, are very scarce and not easily comparable, as there is a wide diversion in definitions and assessment methodologies (Schneider, 2013). For example, recently, the average amount of avoidable food waste reported for Finland was 63 kg/household or 23 kg/person (Koivupuro et al., 2012).

1.2. *The implications of food life cycle in global warming*

Food originating either from plant or animal sources, through its life cycle from production to its final consumption, impacts adversely on global warming, in addition to other numerous natural resources such as land and water which are needed for plants cultivation and animal husbandry (Smith et al., 2007). Agricultural sources of greenhouse gases (GHG) include livestock, nitrogenous fertilizers, rice fields, land-use changes, emissions from agricultural machinery, and biomass burning for land clearing and agricultural purposes (Smith et al., 2007). As a result, different food items pose varying degrees of adverse burdens on global warming. For example, GHG emissions associated with food products from animals include N_2O and CH_4 resulting from animal feed production, from enteric fermentation and manure management (Nijdam et al., 2012). Overall, agriculture in 2005 accounted for 10%–12% of the total global anthropogenic GHG emissions, while it accounted for about 60% of N_2O and about 50% of CH_4 (Smith et al., 2007). The aforementioned impact of food related GHG emissions is projected to increase in the near future because of the simultaneous increase in the world population and in the consumption of animal products (Geeraert, 2013).

Moreover, energy consumption and its associated GHG emissions are related to the transportation, processing, preservation and cooking of food (Carlsson-Kanyama, 1998). For instance, after the production and processing of food and its delivery to our homes, refrigeration and cooking takes place. Both of these activities use energy, mainly in the form of electricity; therefore they put an extra burden on the GHG generation, whose accurate calculation is elusive. For instance, the following generic energy consumption factors are reported for the various ways of cooking: 3.5 MJ/kg for boiling, 7.5 MJ/kg for frying, 0.8 MJ/kg for microwaving and 9.0 MJ/kg for roasting (Muňoz et al., 2010). Regarding the final life cycle stage of food, in most countries food waste ends up in landfills and/or dumps where, due to its high biodegradability, it contributes to the global GHG generation (WRAP, 2009). Overall, GHG emissions associated with food that is wasted are considered as "wasted emissions" or "emissions in vain" (FAO, 2014b). The aim of this paper is the estimation of the GHG emissions associated with food waste generation in Greece. The scope of the research includes both the emissions associated with the production of food and those associated with the management of food waste. The study focuses on households and does not include food waste generated by the food service–catering and the retail–wholesale sectors.

2. Methodology

Food waste contributes in the generation of GHG in two ways. First of all, along with the food wasted, all the GHG emissions generated during the production, processing, distribution, refrigeration, and cooking of food are also wasted. Second, there are the emissions directly resulting from the management of food waste.

Note that, following the recommendations of the analysis by Oldfield and Holden (2014) regarding food waste, our approach is innovative, because it does not take into account the "zero burden assumption" first introduced by Ekvall et al. (2007). The "zero burden assumption" states that the waste coming into a management system is assumed to have a zero environmental burden. In our case, food waste entering the waste management system has already an environmental burden, measured in CO_2 equivalent emissions, resulting from the life cycle of the various food items.

Therefore, in order to estimate the GHG emissions associated with food waste in Greece, the following methodological procedure was followed:

- The food losses prior to the household stage were identified for Greece for the year 2009.
- Data associated with food waste from Greek households were measured (see method below).

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